

acc

JSC 07700
VOLUME XIV
REVISION B

N93-71538

Unclas

29/16 0149877

SPACE SHUTTLE PROGRAM

TM-108229
10/1/77
p. 223

SPACE SHUTTLE SYSTEM PAYLOAD ACCOMMODATIONS

NASA LIBRARY
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS 77058

1

LEVEL II PROGRAM DEFINITION AND REQUIREMENTS VOLUME XIV

(NASA-TM-108229) SPACE SHUTTLE
PROGRAM: SPACE SHUTTLE SYSTEM
PAYLOAD ACCOMMODATIONS. VOLUME 14:
LEVEL 2 PROGRAM DEFINITION AND
REQUIREMENTS (NASA) 223 p



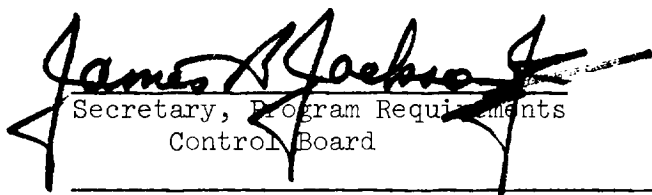
National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER
Houston, Texas

DECEMBER 21, 1973

CHANGE SHEET
FOR
LEVEL II PROGRAM DEFINITION AND REQUIREMENTS
Volume XIV - Space Shuttle Program Payload Accommodations

REVISION B - CHANGE NO. 2

Program Requirements Control Board Directives Nos. 00215 and 00216
March 27, 1974


Secretary, Program Requirements
Control Board

CHANGE INSTRUCTIONS

1. Remove the following listed pages and replace with the same numbered attached pages:

<u>Page</u>	<u>PRCBD No.</u>
i	00215, 00216

2. Place the List of Effective Pages, dated March 27, 1974 directly behind the cover.
3. Sign and date this page in the space provided below to show that the changes have been incorporated and file immediately behind "List of Effective Pages".

Signature of person incorporating changes

Date

LEVEL II PROGRAM DEFINITION AND REQUIREMENTS
Volume XIV - Payload Accommodations (Rev. B)

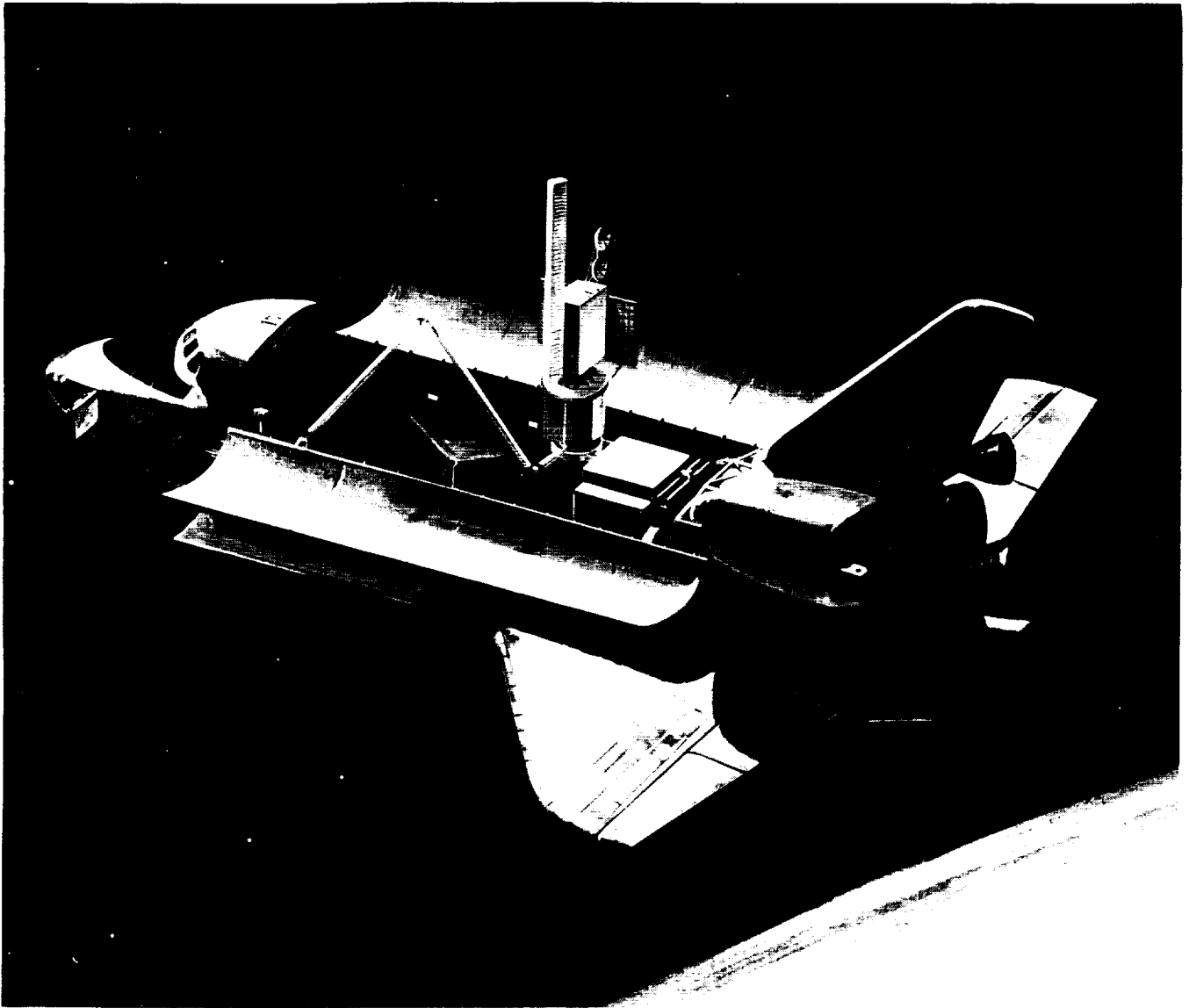
Baseline Issue (Reference PRCBD No. 00151, December 21, 1973)

LIST OF EFFECTIVE PAGES
March 27, 1974

The current status of all pages in this document is as shown below:

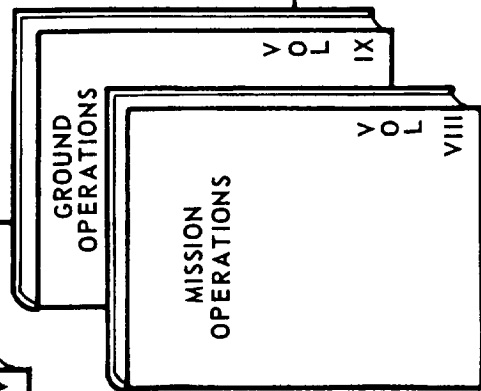
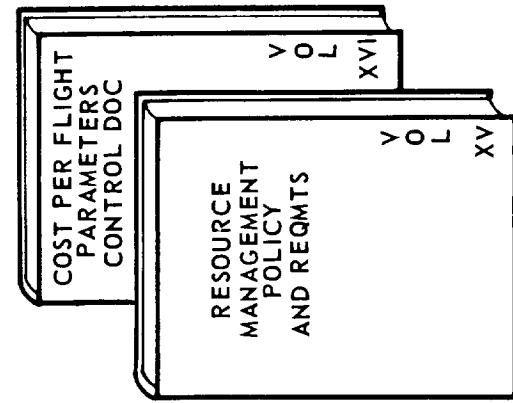
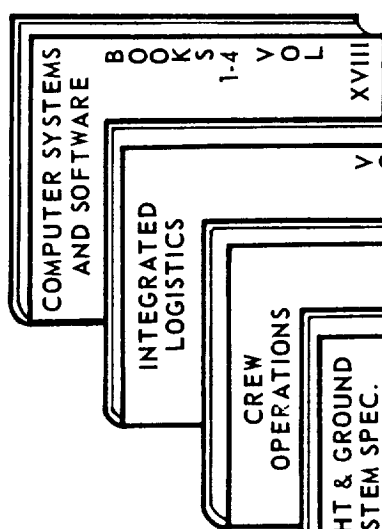
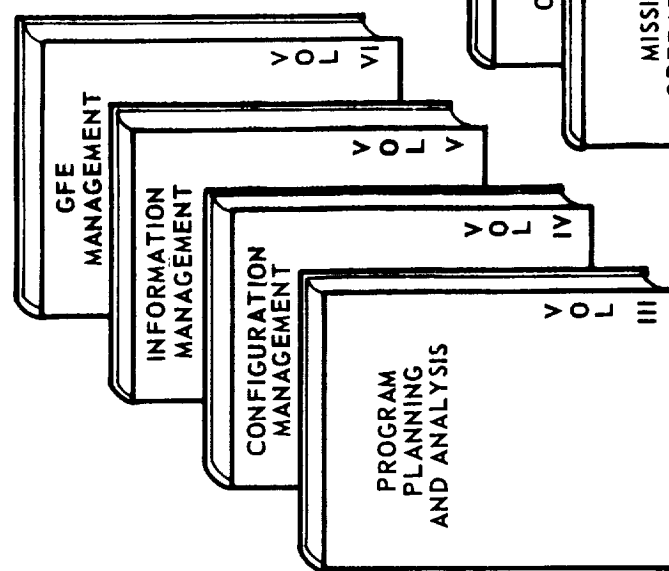
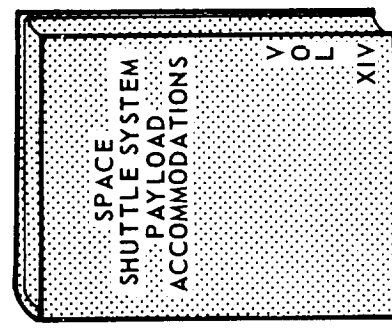
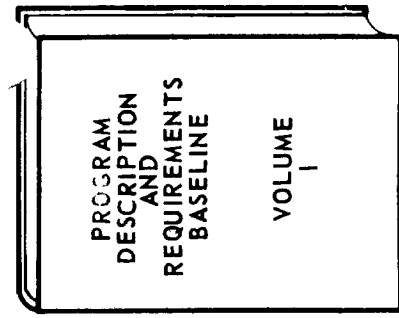
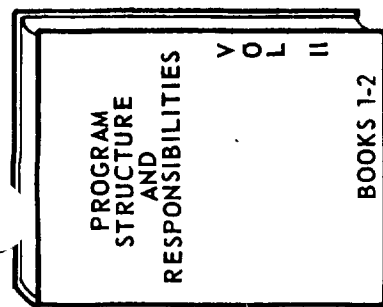
<u>Page No.</u>	<u>Change No.</u>	<u>PRCBD No.</u>	<u>Date</u>
i	2	00215,00216	February 20, 1974
ii - xi	1	00151	December 21, 1973
1-1 - 1-2	1	00151	December 21, 1973
2-1 - 2-8	1	00151	December 21, 1973
3-1 - 3-30	1	00151	December 21, 1973
4-1 - 4-28	1	00151	December 21, 1973
5-1 - 5-8	1	00151	December 21, 1973
6-1 - 6-2	1	00151	December 21, 1973
7-1 - 7-4	1	00151	December 21, 1973
8-1 - 8-8	1	00151	December 21, 1973
9-1 - 9-8	1	00151	December 21, 1973
10-1 - 10-12	1	00151	December 21, 1973
11-1 - 11-2	1	00151	December 21, 1973
12-1 - 12-6	1	00151	December 21, 1973
A-1 - A-2	1	00151	December 21, 1973
B-1 - B-6	1	00151	December 21, 1973
Appendix C	1	00151	December 21, 1973

SPACE SHUTTLE SYSTEM
PAYLOAD ACCOMMODATIONS



JOHNSON SPACE CENTER
HOUSTON, TEXAS

SPACE SHUTTLE
LEVEL II
PROGRAM DEFINITION & REQUIREMENTS
JSC 07700



MANAGEMENT
REQUIREMENTS

NOTE
THE FOLLOWING VOLUME
NUMBERS ARE RESERVED:
VOLUME VII
VOLUME XIII
VOLUME XVII

TECHNICAL REQUIREMENTS

RESOURCE REQUIREMENTS

CHANGE SHEET

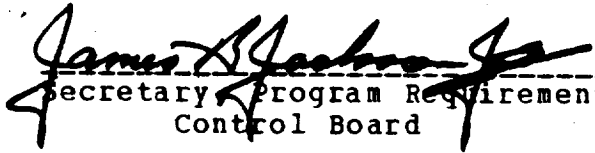
FOR

LEVEL II PROGRAM DEFINITION AND REQUIREMENTS
Volume XIV - Payload Accommodations (Rev. A)

CHANGE NO. 1

Program Requirements Control Board Directive No. 00151

December 21, 1973


Secretary, Program Requirements
Control Board

CHANGE INSTRUCTIONS

1. This is Revision B to JSC 07700, Volume XIV, dated December 21, 1973, which supersedes the original issue dated July 16, 1973. Please discard your Volume XIV dated July 16, 1973, and utilize this Revision B.
2. This Revision B includes the contents of the Revision A with the incorporation of SSR RID's and other changes as shown on the attached SRR RID closeout list.
3. Subsequent changes to Volume XIV will be processed against this Revision B.

The following A&B RID's have been incorporated in JSC 07700,
Volume XIV, Revision B:

<u>RID NO.</u>	<u>LOCATION</u>
11-D-1B	Paragraph 10.4
11-D-13A	Table 4.1
11-D-15	Paragraph 12.0
11-D-48	Paragraph 5.1
11-G-16	Paragraph 5.3.2 & 5.3.3
11-G-17A	Paragraph 5.3.2
11-G-18	Paragraph 5.3.2
11-G-19A	Paragraph 5.3.2
11-J-48A	Paragraph 5.3.1
11-J-58	Paragraph 5.3.2
11-J-62	Paragraph 9.3
11-J-65	Paragraph 2.0
11-L-10A	Paragraph 7.2
11-M-10A	Paragraph 8.2
11-M-11A	Figure 2-1
11-M-12A	Paragraph 4.1
11-M-13A	Paragraph 4.1
11-M-14A	Paragraph 2.0
11-M-17A	Paragraph 4.1
11-M-35A	Paragraph 4.2
11-M-36A	Table 4.1
11-M-37A	Paragraph 4.2
11-M-88A	Paragraph 5.3.2
11-M-182A	Paragraph 4.5
11-M-401A	Paragraph 2.0
11-M-415	Paragraph 4.6
11-R-1	Paragraph 10.4
11-R-5	Paragraph 10.4
1-1-11	Paragraph 4.6
1.2.8	Paragraph 3.2.6
1-3-2	Paragraph 4.4
1-3-4	Paragraph 2.0
2-G-1	Paragraph 5.2
2-A-2	Paragraph 5.1
2-B-102	Paragraph 5.1

(CONTINUED)

<u>RID NO.</u>	<u>LOCATION</u>
2-C-11	Paragraph 5.3
2-F-14AF	Paragraph 5.1
2-1-X	Paragraph 5.3.2.1
2-A-17	Paragraph 5.1
4-0-32 (Part concerning Vol. XIV)	Paragraph 7.1
4-R-25	Figure 7.2, 7.3, 7.4
5-A-46 (Part concerning Vol. XIV)	Figure 4.2
5-H-4	Figure 4-10
7-63	Paragraph 10.4
1-3-5	Glossary
1-3-1	Glossary
11-M-370A	Paragraph 2.0
11-Jp-10	Table 3-1
11-J-84	Figure 4-10
11-J-105	Figure 9-1
11-J-106	Figure 3-9
11-K-4A	Appendix B
11-M-16A	Paragraph 9.4
11-M-32B	Paragraph 10.2
11-M-42A	Paragraph 3.1.2
11-M-43A	Paragraph 7.1
11-M-194A	Paragraph 3.4
11-M-360A	Table 3.1
11-M-411	Figure 3.1
1-2-17	Paragraph 9.4
3-1-19	Paragraph 5.2
11-M-137A	Section 3
11-M-84A	Section 3
11-M-194	Paragraph 3.4
11-J-2A	Paragraph 7.2
7-15	Figures 405, 4-6, 4-7

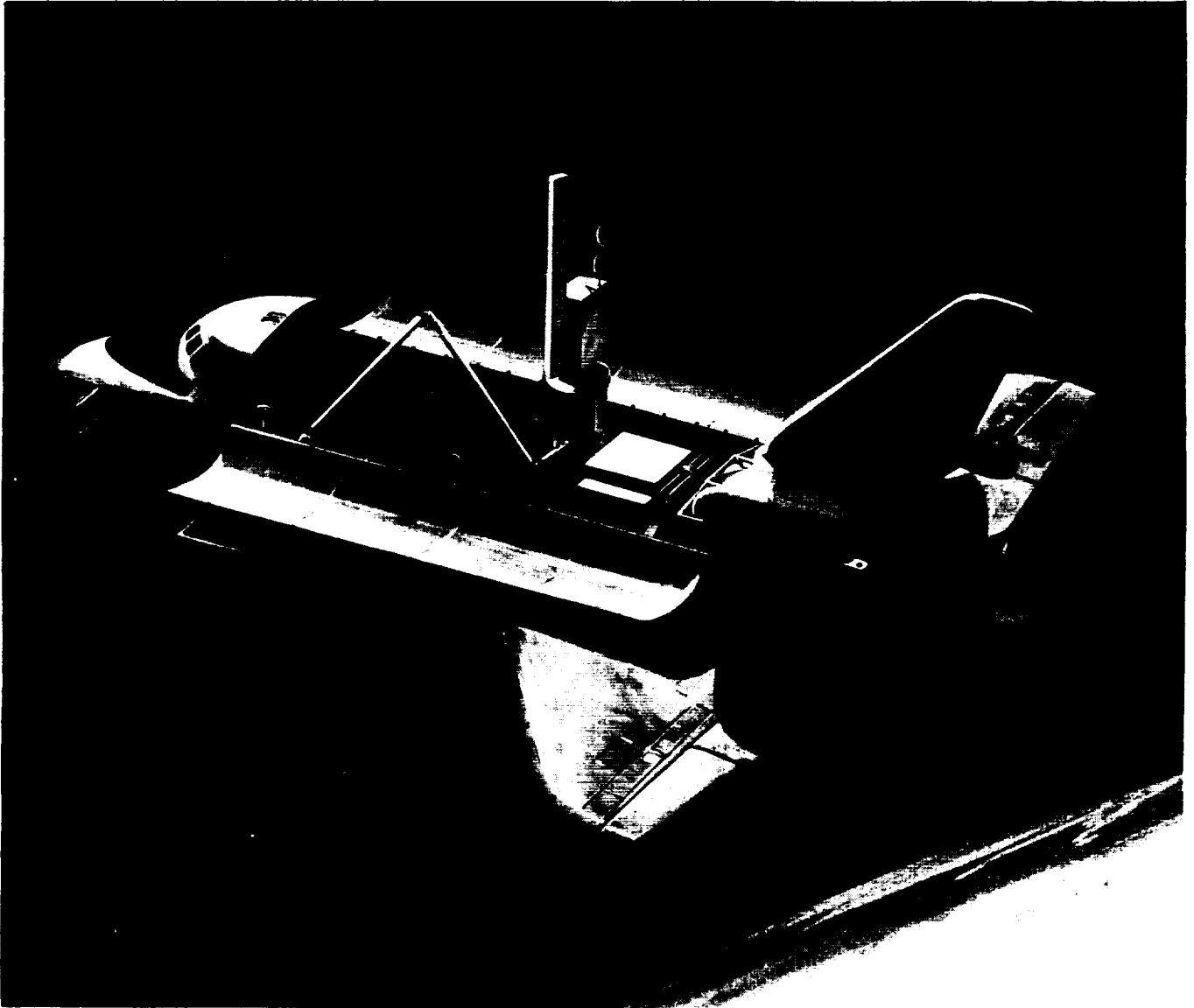
C_RID's_Incorporated

<u>RID_NO.</u>	<u>LOCATION</u>
11-M-194-A	Paragraph 3.4
11-D-11-A	Paragraph 5.3.2.3
11-M-370A	Section 2.0
11-J-106	Paragraph 3.3.6
M-389-B	Paragraph 4.5

Additional_Changes:

- o Revised performance curves based on latest CMS delta V.
- o Rendezvous limits for cooperative and passive targets.
- o Glossary.
- o Revised c.g. curves for longitudinal envelope and tabular values.
- o C.G. curve for vertical c.g. envelope.
- o Vertical CMS kit.
- o Eliminated figure on active thermal control interface temperature.
- o Section 12.0 on KSC ground operations.
- c Appendix C - Payload Accommodations Baseline Drawings.

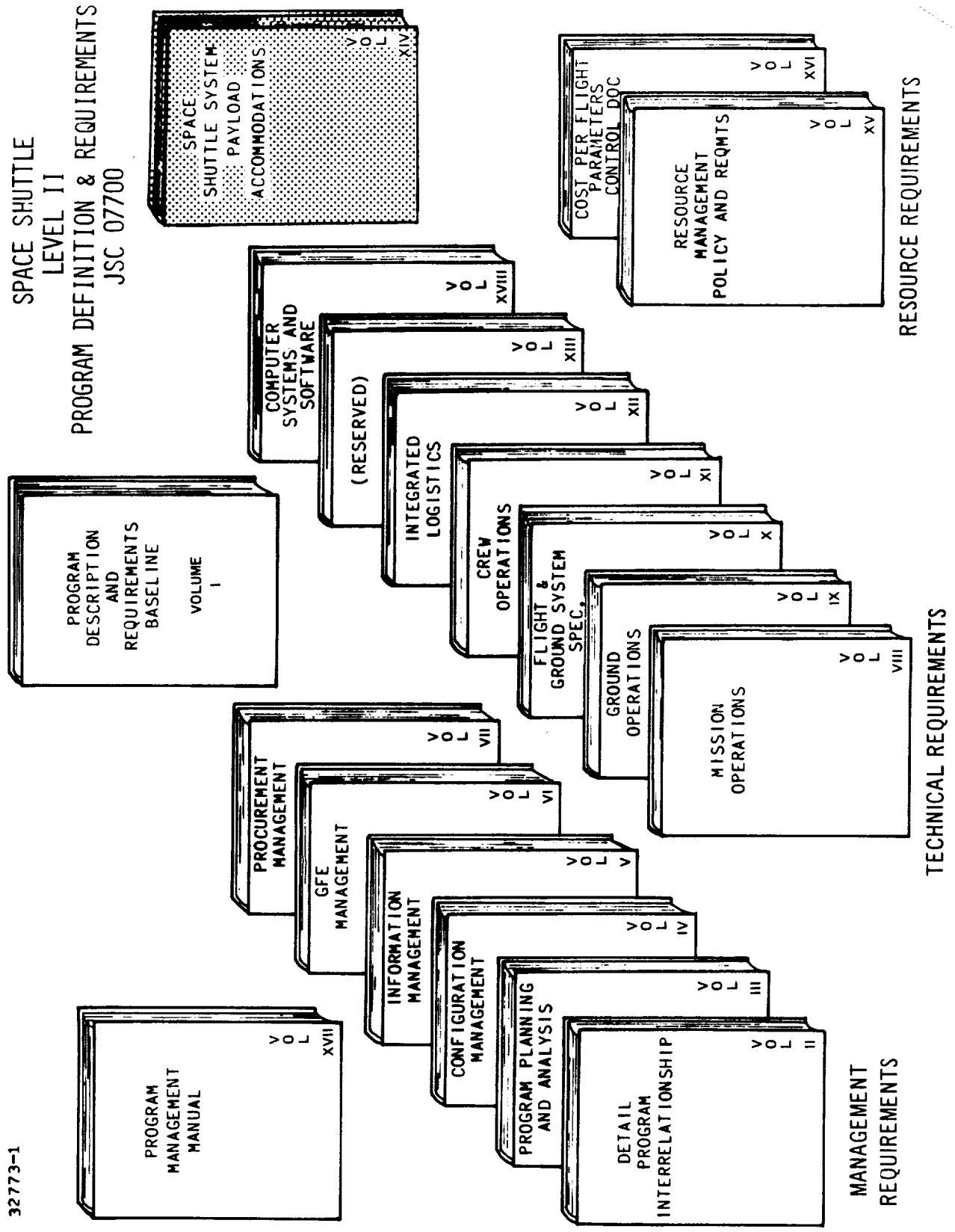
SPACE SHUTTLE SYSTEM
PAYLOAD ACCOMMODATIONS



JOHNSON SPACE CENTER
HOUSTON, TEXAS

32773-1

SPACE SHUTTLE
LEVEL II
PROGRAM DEFINITION & REQUIREMENTS
JSC 07700



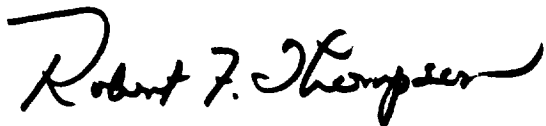
FOREWORD

Efficient management of the Space Shuttle Program dictates that effective controls of program activities be established. To provide a basis for program management; requirements, directives, procedures, interface agreements, and information regarding system capabilities will be documented, baselined, and subsequently controlled by the proper management level.

Program requirements that are to be controlled by the NASA Space Shuttle Program Director (Level I) have been identified and documented in Level I Program Requirements documentation. Program requirements, directives, procedures, etc., controlled by the NASA Space Shuttle Program Manager (Level II) are documented within the volumes of this document, JSC 07700. The accompanying figure identifies the volumes that make up the Level II Program Definition and Requirements baseline. Volume I contains overall descriptions of the contents of the volumes of JSC 07700 and references Level I Program Requirements documentation. Requirements that are to be controlled by the NASA Project Managers (Level III) are to be identified, documented, and controlled at the project level. All elements of the Space Shuttle Program must adhere to these baselined documents and wherein it is considered that the requirements should be waived, deviated from, or changed; the proper waiver, deviation, or change request accompanied by a full justification must be submitted to the proper management level in accordance with established procedures. These documents are to be maintained current by change notices and revisions as required.

This volume of JSC 07700 (Volume XIV) provides the interface definition between the Space Shuttle Flight and Ground System and the payloads. The contents reflect the baseline Space Shuttle System as it is presently configured. It should be clearly understood by the user that during the early stages of the Space Shuttle Program, the detail design and configuration of the Space Shuttle System is subject to change. Until the analyses, design, development, and tests have been completed, the contents of this volume are subject to revision. However, as details of the design are baselined, this document will be revised to reflect firm interface provisions. Questions and recommendations concerning this volume should be addressed to:

Space Shuttle Program Manager, Code LA
Johnson Space Center
Houston, Texas 77058



Robert F. Thompson
Manager, Space Shuttle Program
December 21, 1973

This page intentionally left blank.

CONTENTS

	Page
FOREWORD	ii
1.0 INTRODUCTION	1-1
2.0 SPACE SHUTTLE SYSTEM DESCRIPTION AND GENERAL CAPABILITIES	2-1
3.0 PERFORMANCE	3-1
3.1 Reference Missions	3-1
3.1.1 Reference Mission 1	3-2
3.1.2 Reference Mission 2	3-2
3.1.3 Reference Mission 3A	3-2
3.1.4 Reference Mission 3B	3-2
3.2 Performance Capabilities	3-3
3.2.1 Payload Chargeable Weight	3-3
3.2.2 Launch Azimuths and Inclinations	3-4
3.2.3 Payload Delivery and Retrieval Performance	3-3
3.2.3.1 Circular Orbits	3-4
3.2.3.2 Elliptical Orbits	3-4
3.2.3.3 Sun Synchronous Orbits	3-5
3.3 On-Orbit Capability	3-5
3.3.1 Navigation Accuracy	3-5
3.3.2 Pointing Accuracy	3-5
3.3.3 Vernier RCS Fuel Usage for Limit Cycle Control	3-6
3.3.4 Rotational Maneuvers	3-6
3.3.5 Rendezvous	3-6
3.3.6 Attitude Hold Duration	3-6
3.3.7 Orbit Atmospheric Drag Accelerations	3-6
3.4 Entry Capability	3-7
3.5 Return Payload	3-7
4.0 STRUCTURAL/MECHANICAL	4-1
4.1 Payload Bay	4-1
4.2 Payload Structural Attachments	4-1
4.3 Payload Deployment/Retrieval Mechanism	4-2
4.4 Airlock and Payload Bay Hatch	4-2
4.5 Docking Module	4-3
4.6 Service Panels	4-4
5.0 AVIONICS	5-1

	Page
5.1 Guidance, Navigation and Control.	5-1
5.2 Data Processing and Software.	5-1
5.3 Communications and Tracking	5-2
5.3.1 General	5-2
5.3.2 Functional Description.	5-3
5.3.2.1 Voice Communications.	5-3
5.3.2.2 Telemetry	5-4
5.3.2.3 Commands.	5-5
5.3.2.4 Doppler Tracking.	5-6
5.3.2.5 Television and Wideband Experiment Data . .	5-7
5.3.2.6 Launch Readiness Checkout	5-7
5.3.2.7 Payload Tracking	5-7
6.0 ELECTRICAL POWER.	6-1
7.0 ORBITAL MANEUVERING AND REACTION CONTROL. . . .	7-1
7.1 Orbital Maneuvering Subsystem	7-1
7.2 Reaction Control Subsystem.	7-1
8.0 ENVIRONMENTAL CONTROL AND LIFE SUPPORT.	8-1
8.1 Atmospheric Revitalization Subsystem.	8-1
8.2 Food, Water, and Waste Management Subsystem . .	8-2
8.3 Active Thermal Control Subsystem.	8-2
9.0 CREW PROVISIONS	9-1
9.1 Crew Compartment.	9-1
9.2 Mission Specialist Station.	9-1
9.3 Payload Specialist Station.	9-1
9.4 Payload Handling Station.	9-2
10.0 INDUCED ENVIRONMENT.	10-1
10.1 Vibration.	10-1
10.2 Acoustic	10-1
10.3 Shock.	10-1
10.4 Payload Bay Atmosphere	10-1
10.5 Thermal Environment and Control.	10-2
10.6 Electromagnetic Compatibility.	10-2
10.7 Contamination.	10-2
11.0 SAFETY, RELIABILITY, AND QUALITY ASSURANCE . .	11-1
12.0 KSC SPACE SHUTTLE SYSTEM GROUND OPERATIONS. .	12-1

	Page
APPENDIX A - Abbreviations and Acronyms	A-1
APPENDIX B - Glossary	B-1
APPENDIX C - Payload Accommodations Baseline Drawings	C-1

TABLES

Table		Page
3-1	Mission Timelines	3-8
3-2	Payload Weight Chargeable Items.	3-9
3-3	Expected On-Orbit Navigation Accuracies (3 sigma)	3-12
3-4	Payload Pointing Errors for Earth Targets	3-13
3-5	Effect of Orbital Altitude on RCS Vernier Fuel Usage For Payload Pointing with Various Orbiter Orientations	3-14
3-6	Fuel Usage For Orbiter Sequential Three-Axis Automatic Maneuvers As a Function of Maneuver Rates . . .	3-15
3-7	Rendezvous Limits	3-16
4-1	Payload Bay Limit Load Factors	4-5
4-2	Remote Manipulator System Characteristics.	4-6
10-1	Payload Bay Wall Thermal Environment . .	10-4

FIGURES

Figure		Page
2-1	Space Shuttle Flight System.	2-4
2-2	Mission Phases (Typical)	2-5
2-3	Crew Sizing for Orbiter and Payload Operations	2-6
2-4	Mission Crew Flexibility	2-7
3-1	Launch Azimuth & Inclination Limits from VAFB & KSC	3-17
3-2	Payload Weight vs Circular Orbital Altitude - KSC Launch, Delivery Only.	3-18
3-3	Payload Weight vs Circular Orbital Altitude - VAFB Launch, Delivery Only.	3-19
3-4	Payload Weight vs Inclination for Various Circular Orbital Altitudes - Delivery Only.	3-20
3-5	Payload Weight vs Circular Orbital Altitude - KSC Launch, Delivery and Rendezvous.	3-21
3-6	Payload Weight vs Circular Orbital Altitude - VAFB Launch, Delivery and Rendezvous.	3-22
3-7	Payload Weight vs Inclination for Various Circular Orbital Altitudes - Delivery and Rendezvous.	3-23
3-8	Payload Weight vs Elliptical Orbital Altitude	3-24
3-9	Payload Weight vs Sun Synchronous Orbital Altitude	3-25
3-10	Effect of Attitude Deadband on Orbiter Fuel Usage for Payload Pointer	3-26
3-11	Orbiter Thermal Attitude Constraints	3-27
3-12	Effects of Atmospheric Drag on the Orbiter.	3-28
3-13	Preliminary Direct Reentry Capability.	3-29

Figure		Page
4-1	Orbiter Coordinate System.	4-7
4-2	Payload Coordinate System.	4-8
4-3	Payload Attachment Locations	4-9
4-4	Payload Retention System	4-10
4-5	Payload Longitudinal c.g. Envelope . . .	4-11
4-6	Payload Vertical c.g. Envelope	4-14
4-7	Payload Lateral c.g. Envelope	4-15
4-8	Deployment/Retrieval System.	4-16
4-9	Remote Manipulator System Reach Capability	4-17
4-10	Orbiter Airlock/Docking Module Interface	4-19
4-11	Orbiter Airlock/Habitable Payload Interface with Docking Module.	4-20
4-12	Launch Umbilical Fuel Panel - Preliminary	4-21
4-13	Launch Umbilical Oxidizer Panel - Preliminary	4-22
4-14	Payload Prelaunch (T-18) Umbilical - Preliminary	4-23
4-15	Station 576 Bulkhead Utilities - Preliminary	4-24
4-16	Payload Utilities at Station 576 - Preliminary	4-25
4-17	Station 1307 Bulkhead Utilities - Preliminary	4-26
4-18	Aft Bulkhead Payload Utilities - Preliminary	4-27
7-1	OMS Kit Installation	7-3
7-2	Ninety-Five Percent Envelope of RCS Exhaust Products	7-4
7-3	RCS Thruster Exhaust Cones	7-5
7-4	RCS Vernier Location	7-6

Figure		Page
8-1	Increase in Habitable Payload CO2 Partial Pressure	8-4
8-2	Increase in Habitable Payload Absolute Humidity	8-5
8-3	Increase In Habitable Payload Air Temperature.	8-6
8-4	Habitable Payload Coolant Inlet Temperature.	8-7
9-1	Crew Compartment	9-3
9-2	Crew Compartment Flight Section Crew Stations	9-4
9-3	Crew Compartment Crew Stations, Looking Aft	9-5
9-4	Payload Specialist Station Displays and Control Panels (Preliminary)	9-6
9-5	Field of View Through Aft and Over- head Windows	9-7
10-1	Analytical Predictions of the Orbiter Mid-Fuselage Primary Structure Vibration Spectra	10-5
10-2	Analytical Predictions of the Orbiter Payload Bay Internal Acoustic Environment	10-6
10-3	Analytical Predictions of the Orbiter Payload Bay Internal Acoustic Spectra	10-7
10-4	Payload Bay Purge System	10-8
10-5	Payload Bay Ascent Pressure History	10-9
10-6	Payload Bay Reentry Pressure History	10-10
10-7	Payload Bay Vent System	10-11
12-1	KSC Space Shuttle System Ground Flow	12-3
12-2	KSC Space Shuttle Ground Flow (Preliminary)	12-4
12-3	Horizontal Payload Installation/ Removal Concept	12-5
12-4	Payload Vertical Installation/ Removal Concept	12-6

This page intentionally left blank.

1.0 INTRODUCTION

This document describes the Space Shuttle system as it relates to payloads. Its purpose is to provide potential users of the Space Shuttle System with an official source of information on the planned accommodations for payloads and the definition of the interface between the payloads and the Space Shuttle System. By utilizing this information, payload planning and design studies can be conducted against a controlled set of accommodations and interface provisions. It describes a baseline configuration of the Space Shuttle System which is consistent with current Space Shuttle Program requirements. It includes performance data and information on subsystems, environment, and support equipment. It contains those "design to" requirements for payloads which must be utilized in the payload design and development in order to be compatible with the Space Shuttle System.

PRECEDING PAGE BLANK NOT FILMED

This page intentionally left blank.

2.0 SPACE SHUTTLE SYSTEM DESCRIPTION AND GENERAL CAPABILITIES

The Shuttle Flight System is composed of the Orbiter, an External Tank containing the ascent propellants to be used by the Orbiter main engines, and two Solid Rocket Boosters (SRB's). The Shuttle Flight System is shown in Figure 2-1.

The SRB's and the Orbiter main engines fire in parallel, providing thrust for lift-off. The Orbiter main engines continue firing until the vehicle reaches the desired sub-orbital conditions where the External Tank is jettisoned. The orbital maneuvering subsystem (OMS) is immediately fired to place the Orbiter in the desired final orbit. The mission phases representing a typical operational sequence are illustrated in Figure 2-2. The Orbiter delivers and retrieves payloads, conducts orbital operations, and returns to a land base in a manner similar to that of high-performance aircraft.

The Orbiter shown in Figure 2-1 is a reusable vehicle designed to operate in orbit for missions up to 7 days duration. However, the Orbiter is being designed so as not to preclude missions of longer duration up to 30 days from being accomplished. The crew and other personnel will be accommodated in a shirt-sleeve environment in a two-level pressurized cabin with an airlock that provides access to the payload bay and permits extravehicular activity (EVA). The cabin is being designed for a basic crew of four with expendables provisioning for 28 mandays. Provisioning storage capacity is being provided for a total provisioning capability of 42 mandays.

The Orbiter crew consists of the commander and pilot. Additional crewmen which may be required to conduct Orbiter/payload operations are a mission specialist and a payload specialist. The duties of the crew are defined as follows:

Commander. The commander will be in command of the flight and will be responsible for the overall space vehicle operations, personnel, payload flight operations, and vehicle safety. He will be proficient in all phases of vehicle flight, payload manipulation, and docking; and, in subsystem command, control, and monitor operation. He also will be knowledgeable of payload and payload systems as they relate to flight operations, communication requirements, data handling, and vehicle safety.

PRECEDING PAGE BLANK NOT FILMED

Pilot. The pilot will be second in command and will be equivalent to the commander in proficiency and knowledge of the vehicle. He will normally perform the payload deployment/retrieval operations via the remote manipulator system and will be the back-up crewman for EVA operations.

Mission Specialist. The mission specialist is operationally oriented, and his background/training will be commensurate with the type of payload flown on specific missions. He will work with and assist the payload specialist during payload operations. He is responsible for interfacing and management of payload and Orbiter subsystem operations. He is proficient in vehicle and payload subsystems, flight operations, and payload communications data management and will be the prime crewman for EVA operations.

Payload Specialist. The payload specialist will be responsible for the applications, technology, and science payload/instruments operations. This specialist will have detailed knowledge of the payload/instruments, operations, requirements, objectives, and supporting equipment.

The crew size and crew mix will be a function of the mission complexity and duration. Figure 2-3 gives an estimate of the crew size required for typical missions and Figure 2-4 gives the crew flexibility which can be utilized in mission planning.

The Orbiter will provide the capability to perform three, two-man, 4-hour duration EVA's. An airlock is provided so that depressurization of the crew cabin is not required to perform EVA. The nominal EVA equipment uses water venting to provide personnel cooling. Voice communication between the EVA crewmen and the Orbiter and the EVA crewmen and the ground is provided by the Orbiter. Crewman restraints can be located either on the payload or in the Orbiter payload bay as required for optimum operational capability.

The Orbiter will be capable of rendezvous and retrieval of a cooperative or passive payload under daylight and darkness conditions. Exterior lighting and interior lighting within the payload bay will be provided on the Orbiter to aid in these operations and other Orbiter/payload orbital operations.

A 15-feet (4.57 m.) diameter by 60-feet (18.29 m.) long payload envelope is provided with payload attach fittings and alignment guides, a payload deployment/retrieval mechanism, and standard interface connectors for Orbiter/payload services. Interface provisions for payload propulsive stage fill, vent, and drain are also provided.

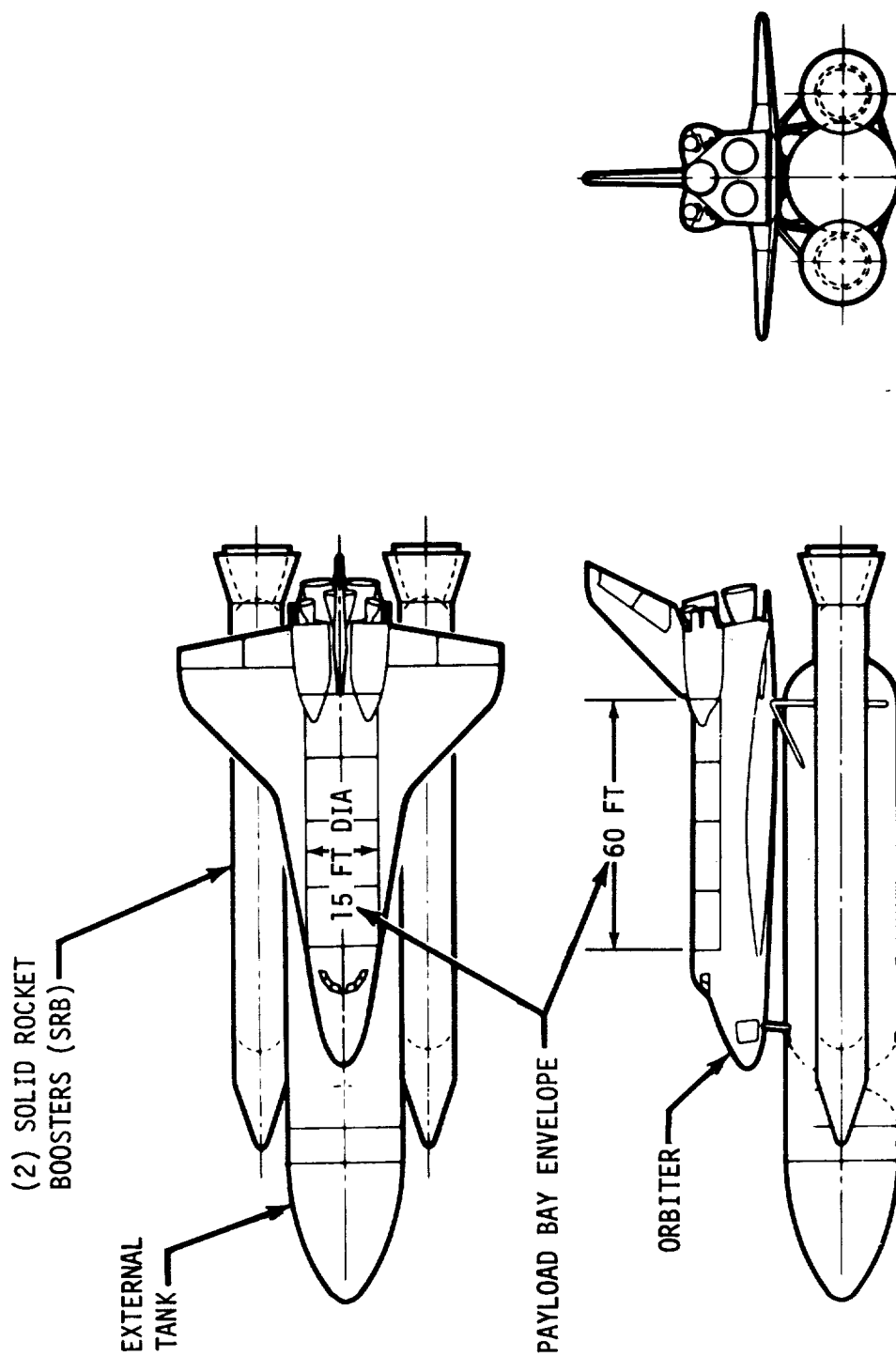


FIGURE 2-1. - SPACE SHUTTLE FLIGHT SYSTEM

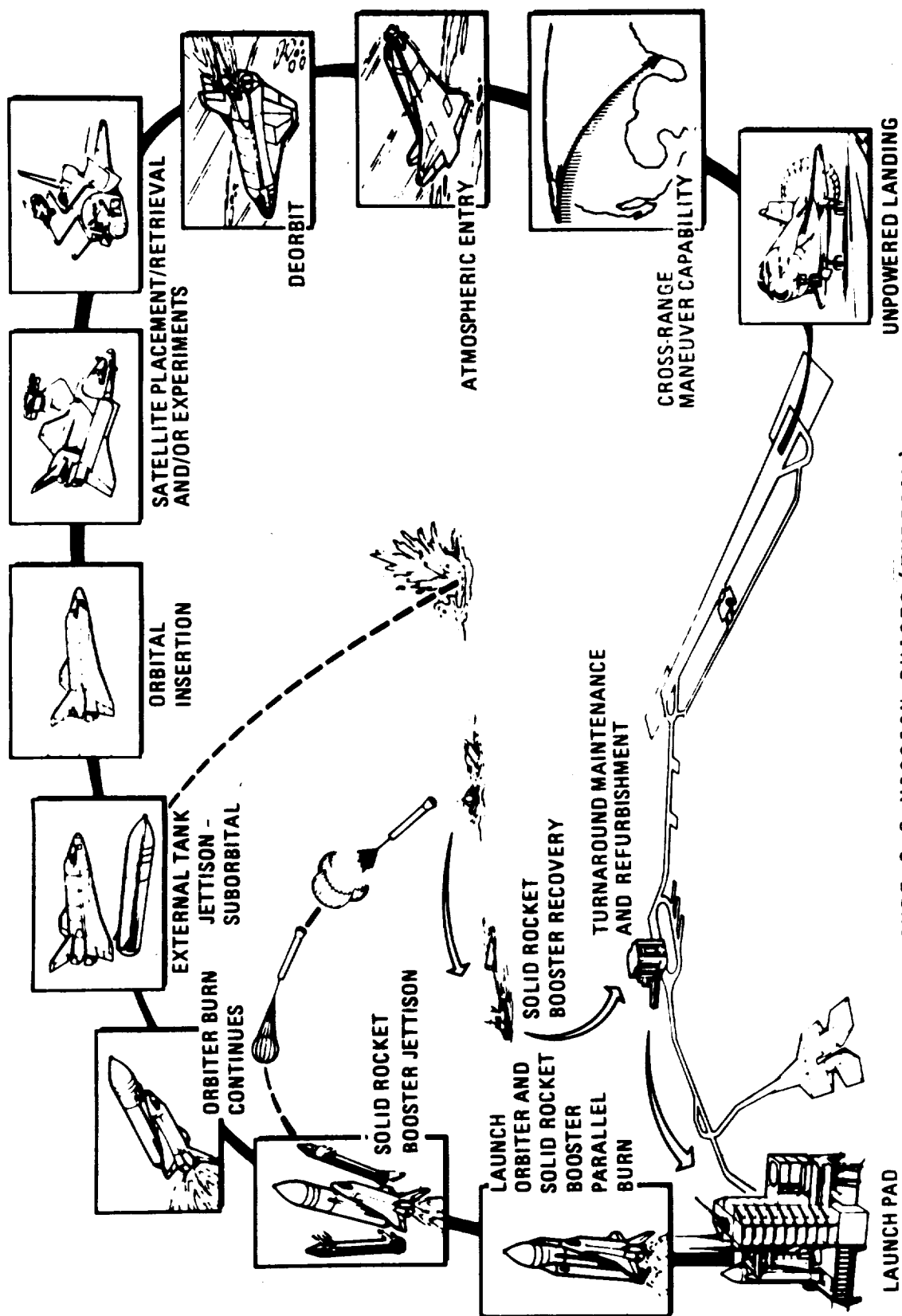


FIGURE 2-2 MISSION PHASES (TYPICAL)

MISSION TYPE	PAYLOAD CARRIER	TOTAL NUMBER OF CREWMEN		REMARKS/SKILLS REQUIRED
		1 SHIFT	2 SHIFT	
SORTIE (7 DAY MISSION)	SPACELAB WITH/WITHOUT PALLET	2 OR 3 PLUS 2-4 PS's IN LAB (7 TOTAL MAX)	3, PLUS 4 MAX PS's IN LAB (7 TOTAL MAX)	TWO INTERFACE SYSTEMS SPECIALISTS REQUIRED TO SUPPORT 2-SHIFT OPERATION. CROSS-TRAINING OF PILOT ALLOWS TOTAL OF 3 OPERATIONS CREWMEN OR POSSIBILITY OF ONLY 2 ON SINGLE SHIFT.
SORTIE (7 DAY MISSION)	PALLET ONLY	3-4	6	TWO CREWMEN SUPPORTING PAYLOAD OPERATIONS ON EACH SHIFT, PLUS PILOT.
EARTH ORBITAL PAYLOAD DEPLOYMENT AND RETRIEVAL (7 DAY MISSION)	ORBIT-TO-ORBIT STAGE AND PAYLOAD	3-4	6	MANNING SIMILAR TO SORTIE - PALLET MISSION, YET FUNCTIONS VARY. HIGH DEGREE OF COMPLEXITY IN PAYLOAD INTER-FACE SYSTEMS
EARTH ORBITAL RETRIEVAL (DURATION 1-16 REVS)	FREE FLYER (EOS, ETC)	3-4	5-6	VARIATIONS IN MANNING DEPENDENT UPON PAYLOAD CONTROL, MONITORING. PRIME ACTIVITIES ARE RF COMMAND, COMMUNICATIONS WITH PAYLOAD AND VEHICLE PLUS MANIPULATOR CONTROL.
EARTH ORBITAL OPERATION	AUTOMATED PAYLOAD (REQUIRES) ONLY START AND SHUT-DOWN FOR ON ORBIT OPERATION)	2	2-3	NO CREW INVOLVEMENT WITH PAYLOAD EXPERIMENT SENSOR OPERATION. MORE THAN ONE CREWMAN MAY BE REQUIRED PER SHIFT, DEPENDING ON VEHICLE AND PAYLOAD INTER-FACE WORKLOAD.

FIGURE 2-3. - CREW SIZING FOR ORBITER
AND PAYLOAD OPERATIONS
2-6

ORBITER FLIGHT OPERATIONS

- VEHICLE FLIGHT CONTROL
- GUIDANCE, NAVIGATION
- VEHICLE SYSTEMS MANAGEMENT
- MONITOR, CONTROL FLIGHT SAFETY ITEMS
- RENDEZVOUS AND DOCKING
- MANIPULATOR OPERATIONS
- CONSUMABLES MANAGEMENT
- ACTIVITY SCHEDULING

PAYLOAD/ORBITER INTERFACE FUNCTIONS

- ORBITER/PAYLOAD SUBSYSTEM CHECKOUT, OPERATION
- MONITOR PAYLOAD CAUTION AND WARNING
- MANAGE PAYLOAD SUPPORT COMMUNICATIONS
- ELECTRICAL POWER MANAGEMENT
- ENVIRONMENTAL CONTROL
- ASSIST IN EXPERIMENT OPERATIONS AND MAINTENANCE
- CONSUMABLES MANAGEMENT
- ACTIVITY SCHEDULING
- PRIME FOR EVA OPERATIONS

PAYLOAD OPERATIONS

- PERFORM EXPERIMENTS INITIATION, OPERATION, MONITORING
- EXPERIMENT DATA MANAGEMENT
- PERFORM PAYLOAD MAINTENANCE
- INTERFACE WITH GROUND EXPERIMENTERS AS REQUIRED
- ACTIVITY SCHEDULING
- PAYLOAD HOUSEKEEPING OPERATIONS
 - PAYLOAD SYSTEMS MONITORING
 - CONSUMABLES MANAGEMENT

- ▶ PRIMARY FUNCTION
- ▬ OPTION WITH CROSS-TRAINING
- LIMITED DUTY BASIS

CDR	PILOT	MISSION SPEC.	PAYLOAD SPEC.
▶	▶	●●●●●●●	
▬	▬	▬	
●●●●●	●●●●●	●●●●●	▬

FIGURE 2-4. - MISSION CREW FLEXIBILITY

This page intentionally left blank.

3.0 PERFORMANCE

3.1 Reference Missions. The Space Shuttle System is to provide a general capability for the transportation of a wide variety of payloads to and from low earth orbit altitudes at various inclinations. To accomplish this goal, reference missions have been selected for design purposes which are representative of the wide spectrum of anticipated missions.

The launch technique uses a sub-orbital External Tank separation. Reference Missions 1 and 2 would be launched from the Kennedy Space Center (KSC) with Main Engine Cutoff (MECO) occurring on a sub-orbital trajectory targeted so that the External Tank will impact in the Indian Ocean. Immediately after MECO the Orbiter separates and the orbital maneuvering subsystem (OMS) is used to place the Orbiter in the desired final orbit. Reference Mission 3A and 3B would be launched from Vandenberg Air Force Base (VAFB) into a similar sub-orbital trajectory targeted to impact the external tank in the Pacific Ocean. MECO conditions from VAFB are at a lower velocity than from KSC because the potential tank impact areas are closer to the launch site.

On-orbit translational delta-V is provided by the orbital maneuvering subsystem (OMS) and the reaction control subsystem (RCS). The OMS provides the propulsive thrust to perform orbit circularization, orbit transfer, rendezvous and deorbit maneuvers. The RCS provides the propulsive thrust for three-axis angular control and three axis-translation of the Orbiter. The Orbiter will have the capability to use either the parking orbit technique or the direct ascent technique for rendezvous. In using the parking orbit technique, all orbit transfer maneuvers required to establish a terminal approach to the payload will be executed using the OMS. In using the direct ascent technique, the Orbiter is launched into an intercept trajectory at the same inclination as the target. In using either technique, rendezvous braking maneuvers will be executed with the RCS.

The on-orbit translational delta-V stated for each reference mission is the delta-V required for the on-orbit maneuvers dictated by that mission and includes on-orbit delta-V reserves and delta-V required for de-orbit. This delta-V is in excess of that required to achieve the insertion orbit and required for on-orbit and entry attitude control.

3.1.1 Reference Mission 1. Reference Mission 1 is a payload delivery mission to a 150-nautical mile circular orbit and a rendezvous and retrieval of a reusable payload from a 160 nautical mile circular orbit. The mission will be launched due east, and requires a payload delivery capability of 65,000 pounds. The boost phase will provide insertion into an orbit with a minimum apogee of 100 nautical miles followed by two OMS maneuvers that establish a 150 nautical mile circular orbit. Payload release and its transfer maneuver will occur within the first day followed by approximately five days of on-orbit activities. The seventh day activities will include rendezvous, payload retrieval, deorbit and landing. The Orbiter on-orbit translation delta-V requirement is 650 feet per second (fps) from the OMS and 100 fps from the RCS.

3.1.2 Reference Mission 2. Reference Mission 2 is a combination revisit to an orbital element in a 270-nautical mile circular orbit at 55 degrees inclination and orbital experiment operations. The boost phase will provide insertion into an orbit with a minimum apogee of 100 n.m. followed by orbit circularization and rendezvous phasing initiation for a coelliptic maneuver sequence at the first apogee. Rendezvous, berthing or station keeping, and refurbishment will occur within the first day, followed by approximately five days of experiment operations. The seventh day activities will include de-orbit and landing. This mission requires a payload capability of 25,000 pounds. The Orbiter on-orbit translational delta-V requirement is 1,250 fps from the OMS and 120 fps from the RCS.

3.1.3 Reference Mission 3A. Reference Mission 3A is a payload delivery mission to a 50 by 100-nautical mile orbit at 104 degrees inclination and return to the launch site in a single revolution. This mission requires a payload delivery capability of 32,000 pounds and a return payload weight of 2500 pounds. The Orbiter on-orbit translation delta-V requirement is 250 fps from the OMS and 100 fps from the RCS.

3.1.4 Reference Mission 3B. Reference Mission 3B is a payload retrieval mission from a 100-nautical mile circular orbit at 104 degrees inclination and return to the launch site in one revolution. This mission requires a payload delivery capability of 2500 pounds and a retrieval capability of 25,000 pounds. The Orbiter on-orbit translation delta-V is 425 fps from the OMS and 190 fps from the RCS. A typical mission timeline for Reference Mission 3A and 3B is given in Table 3-1.

3.2 Performance Capabilities. The performance capabilities of the Space Shuttle System are dependent on the operational requirements established for each mission. The type of rendezvous technique; the payload pointing requirements; the operational constraints; length of mission; orbit transfer requirements; etc., determine the performance capability for any particular mission. The performance curves contained in this section represent the capabilities of the Space Shuttle System for typical sets of operational requirements. Certain items of equipment, consumables, etc., which are mission unique must be considered as part of the total payload, and in planning for a particular mission must be included as part of the payload weight. In addition, the OMS and RCS are loaded to meet the specific on-orbit maneuver requirements and not necessarily to the total loading capacity.

The Orbiter integral OMS tankage has been sized to provide 1,000 fps delta-V capability to the Orbiter with a 65,000 pound payload. Up to three extra OMS kits can be installed for increased operational flexibility. Each kit contains one-half as much usable propellant as the integral OMS tankage resulting in a total propellant capacity 2.5 times that of the integral tankage.

3.2.1 Payload Chargeable Weight. The payload chargeable weight is the weight of additional personnel in excess of a crew of four, OMS kits, docking module, additional consumables, and payload support equipment which are added to the basic Orbiter for a particular mission, in excess of the basic Orbiter capability. Many of these items are available in the Space Shuttle hardware inventory but must be listed separately in the Orbiter weight summary for the purpose of weight accounting.

To determine the payload weight for mission planning, the user should add the weight of his payload with the selected payload weight chargeable items listed in Table 3-2. This weight can then be compared to the values given on the performance curves to verify the capability of the Space Shuttle System to perform the desired mission. It should be noted that the weight of the OMS kits has been included in these curves.

3.2.2 Launch Azimuths and Inclinations. The operational launch azimuths from the two planned launch sites and the orbital inclinations obtainable are shown in Figure 3-1. The operational constraints for launch azimuths greater than 201 degrees are under study.

3.2.3 Payload Delivery and Retrieval Performance.

3.2.3.1 Circular Orbits. Figures 3-2 and 3-3 show payload delivery capability as a function of circular orbital altitude at various inclinations. Figure 3-2 is for missions launched from KSC and Figure 3-3 is for missions launched from VAFB. Separate plots are needed because of the different MECO conditions required for the two different launch sites. Figure 3-4 is the same data plotted to permit more accurate determination of payload delivery capability for a particular inclination. On this figure, the total CMS delta-V identified for each circular orbital altitude is that required to deliver a payload to that altitude and inclination, and is constant for the particular altitude curve. This delta-V does not include the OMS delta-V used between MECO and the reference 50 x 100 nautical mile insertion altitude. The curves are plotted based on a launch from KSC for inclinations less than 56° and VAFB for inclinations above 56°. The RCS propellant loading is 4,500 pounds and a 22 fps OMS delta-V reserve is maintained to correct for dispersions. Figures 3-5 and 3-6 show the same type of information except that rendezvous has been included. In generating this information for the rendezvous case, the RCS propellant loading is 6,300 pounds with a 42 fps OMS delta-V reserve maintained to correct for dispersions. The RCS total usable propellant capacity is TBD. The performance shown on Figures 3-2 through 3-7 is based on carrying the entire payload throughout all delta-V maneuvers. This would allow the Orbiter to de-orbit if for any reason the payload could not or should not be deployed.

3.2.3.2 Elliptical Orbits. Figure 3-8 shows the payload delivery capability as a function of elliptical orbital altitude. MECO conditions are the same as for all KSC launches with the OMS providing the propulsive thrust to circularize at 100 nautical mile orbital altitude and then to place the Orbiter into the desired elliptical orbit. The curve which shows de-orbit from 100 nautical miles is based on the Orbiter returning to a 100 nautical mile circular orbit prior to re-entry. The curve which shows direct de-orbit is the maximum elliptical orbit achievable and assumes initiation of the de-orbit maneuver at apogee. This curve does not recognize operational limitations such as the relationship of the landing site to the initiation of the de-orbit maneuver or constraints due to thermal protection system capabilities. Therefore, the elliptical orbit capability shown by this curve may be restricted, and these possible restrictions should be duly considered in mission planning.

3.2.3.3 Sun Synchronous Orbits. Figure 3-9 shows the payload weight as a function of sun synchronous orbital altitude. The solid curve is payload delivery only, and the dashed curve is for payload delivery, including rendezvous. These curves expand the data shown on Figures 3-4 and 3-7 for sun synchronous missions.

3.3 On-Orbit Capability.

3.3.1 Navigation Accuracy. The expected on-orbit navigation accuracies using the Spaceflight Tracking and Data Network (STDN) and the Tracking Data Relay Satellite System (TDRS) are given in Table 3-3. For each system the estimated state errors are given at the end of the last data tracking pass (i.e., local) and for one revolution later. The navigation accuracies using the STDN are based on at least two tracking passes of at least a 5° elevation angle separated by approximately one revolution. The TDRS navigation accuracies are based on two tracking passes from a single TDRS.

3.3.2 Pointing Accuracy. The Orbiter has the capability of achieving and maintaining any desired space or earth referenced attitude for payload pointing purposes within the thermal attitude constraints defined in Paragraph 3.3.6. Payload pointing is accomplished by accepting data from a payload supplied and payload mounted sensor. The pointing capability for inertial pointing is dependent on the error source from the sensor and the Orbiter control system deadband. For earth pointing an additional error, navigation, has to be included. Simulations have been conducted on the Orbiter system for deadbands down to ± 0.1 degree/axis. Using a deadband of ± 0.1 degree/axis and a payload mounted sensor with an accuracy of approximately ± 0.07 degrees alignment and ± 0.04 degrees drift/hour a 3 sigma inertial pointing capability of ± 0.16 degrees is obtained. If a sensor of much greater accuracy is used the pointing accuracy will approach that of the deadband. At present simulations have not been conducted on deadbands less than ± 0.1 degs/axis nor has the effects of structural deformation been included such that an absolute minimum deadband has not been determined. Table 3.4 gives the expected errors for pointing at earth targets. The accuracies given for earth targets looking both vertical and 30 degrees off the vertical are for pointing at a point on earth at a specific time and are based on a ± 0.1 degree deadband and a sensor accuracy of ± 0.07 degrees alignment and ± 0.04 degrees drift/hour.

3.3.3 Vernier RCS Fuel Usage for Limit Cycle Control. The Vernier RCS fuel usage for various orbital altitudes and vehicle orientation modes are presented in Table 3.5 for a per axis deadband of ± 0.1 degrees. These consumption rates include both aerodynamic and gravity gradient torques. The effects of attitude deadband on Vernier RCS fuel usage for payload pointing in a 100 n.mi. circular orbit are illustrated in Figure 3.10. For deadbands greater than 0.1 degrees, the majority of the fuel is utilized for countering the aerodynamic and gravity gradient disturbances. The values given for deadbands less than 0.1 degree are based on analytical predictions using an ideal limit cycle and also include the aerodynamic and gravity gradient disturbances.

3.3.4 Rotational Maneuvers. The RCS system is used for Orbiter rotational maneuvers (e.g. from stellar inertial to local vertical). The time available to perform these maneuvers is based on the particular mission constraints. Table 3.6 gives the fuel usage for Orbiter sequential three-axis automatic maneuvers at maneuver rates from 0.25 to 1.0 deg/sec. All maneuvers were 10 degrees in each axis. The fuel usage is based on using the RCS thrusters because the angular acceleration of the vernier thrusters is quite small. The fuel usage, however, would be essentially the same since the specific impulse and moment arms of the two systems are comparable.

3.3.5 Rendezvous. The Orbiter will have the capability to rendezvous with orbiting payloads that are either cooperative or passive. In most cases it will use a multi-orbit and multi-impulse maneuver sequence associated with a parking orbit rendezvous mode, but it is also capable of performing a rendezvous and retrieval in one revolution as depicted by Reference Mission 3B. The rendezvous limits for cooperative and passive targets are given in Table 3.7.

3.3.6 Attitude Hold Duration. The Orbiter thermal design reference missions are based on the worst case attitude hold orientation (solar incidence angle, $B = 90^\circ$) and local vertical mode with either the X or the Y axes perpendicular to the orbital plane. The orbiter attitude constraints due to the thermal design are presented in Figure 3-11.

3.3.7 Orbit Atmospheric Drag Accelerations. On-orbit acceleration levels resulting from atmospheric drag on the Orbiter while in a drift mode of operation are shown in Figure 3-12. Perturbations such as crew movement, venting,

etc., would affect acceleration levels in this mode of operation.

3.4 Entry Capability. The preliminary direct reentry capability of the Orbiter as a function of payload weight and orbit inclination is shown in Figure 3-13. This figure only presents the direct reentry capability and does not indicate the launch capability which in some instances is less than the re-entry capability. This reentry capability was based on the thermal protection system (TPS) initial conditions associated with Reference Mission 3A. By preconditioning the TPS prior to reentry the direct reentry capability increases as evidenced by the right hand curve.

3.5 Return Payload. The Orbiter is being designed to operationally de-orbit and land with a 32,000 pound maximum payload weight. Payloads which are to be returned from orbit should not exceed this value. The Orbiter can under abort or emergency conditions safely return and land with payloads in excess of 32,000 pounds with reduced margins of safety.

TIME

GET HR:MIN:SEC

Mission 3A Mission 3B

Lift-off	00:00:00	00:00:00
SRL Staging	00:02:07	00:02:07
Main Engine Cut-off	00:08:09	00:08:32
ET Separation	00:08:32	00:08:55
OMS Burn (Ignition)	00:08:54	00:09:17
OMS Cut-off (Orbit Insertion)	00:12:01	00:12:04
Open Payload Bay Doors	00:15:45	00:16:15
Start Payload Deployment Operations	00:16:45	
Release Payload	00:36:10	
Translate Orbiter (200 feet) (RCS)	00:36:30	
Orbiter Separation Maneuver (RCS)	00:42:00	
Close Payload Bay Doors	00:42:15	
Start Payload Target Tracking		00:19:15
Start Braking Burns		00:24:49
Complete Braking Burns		00:33:00
Maneuver to Retrieval Attitude & Pos.		00:35:15
Start Payload Retrieval Operations		00:38:15
Grapple Payload		00:39:55
Retract and Secure Payload in Bay		00:48:31
Close Payload Bay Doors		00:49:01
Orbiter Deorbit Burn (OMS)	00:59:15	00:59:44
Entry Interface (400K feet)	01:10:05	01:10:40
TAEM Interface (70K feet)	01:41:58	01:42:58
Touchdown	01:49:11	01:50:28

TABLE 3-1.- Mission Timelines
(Missions 3A & 3B - 104° Inclination)

ITEM	DESCRIPTION/REMARKS	LANDED		EXPENDED		PAYLOAD BAY CLEAR VOLUME INTRUSION
		WT (LB)	\bar{X}_0 CG ³	WT (LB)	\bar{X}_0 CG ³	
OMS ΔV	1 KIT	2,365	1,280	11,912	1,280	57 INCHES
	2 KITS	3,505	1,257	23,824	1,257	103 INCHES
	3 KITS	4,715	1,236	35,736	1,236	145 INCHES
RCS PROPELLANT	EXCESS CAPACITY IN FWD TANKS	-	-	MISSION DEPENDENT		NONE
DOCKING ADAPTER	DOCKING MODULE	TBD	632			
	FWD TRANSFER TUNNEL	TBD	585	-	-	NONE
	ATTACH FITTING SET, 4-POINT	TBD	644	-	-	NONE
TRANSFER TUNNEL	DOCKING MODULE TO PAYLOAD, 12-IN. MIN	400	679	-	-	12 IN. MIN
	VARIABLE LENGTH TUNNEL TO PAYLOAD	TBD(1)	TBD(1)	-	-	TBD
EVA/IVA	PGA & EVLSS/ELSS	150 EA	538(2)	-	-	NONE
	DRYER & RECHARGE FACILITY	TBD	TBD	-	-	NONE

(1) DEPENDENT ON PAYLOAD DESIGN

(2) ζ AIRLOCK

(3) C.G. LOCATION OF ITEM ON ORBITER X AXIS

TABLE 3-2. - PAYLOAD WEIGHT CHARGEABLE ITEMS

PAGE 1 OF 3

ITEM	DESCRIPTION/REMARKS	LANDING		EXPENDED		PAYLOAD BAY CLEAR VOLUME INTRUSION
		WT (LB)	\bar{X}_0 CG ³	WT (LB)	\bar{X}_0 CG ³	
SERVICE PANELS	PAYLOAD UNIQUE (T-18) GROUND SERVICING CRYO FILL, DRAIN, & DUMP STORABLE FILL, DRAIN, & DUMP	TBD STA 1307 TO PAYLOAD TBD		- - -	- - -	NONE
PAYLOAD RETENTION	STRUCTURAL SUPPORT SET, 4-POINT AFT TILT TABLE FOR ORBIT-TO-ORBIT STAGE		MISSION DEPENDENT 1300	- -	- -	NONE
MANIPULATOR ARM	PAYLOAD PROVIDED 2ND UNIT	615	835	-	-	NONE
ATMOSPHERIC CONTROL & REVITALIZATION	GREATER THAN BASELINE	PAYLOAD DEPENDENT	CABIN	-	-	NONE
DISPLAYS & CONTROLS	PAYLOAD UNIQUE	PAYLOAD DEPENDENT	CABIN	-	-	NONE

TABLE 3-2. - PAYLOAD WEIGHT CHARGEABLE ITEMS
PAGE 2 OF 3

ITEM	DESCRIPTION/REMARKS	LANDED		EXPENDED		PAYLOAD BAY CLEAR VOLUME INTRUSION
		WT (LB)	X ₀ CG3	WT (LB)	X ₀ CG3	
ADDITIONAL CREW: 5TH TO 7TH	PASSENGERS SEATS & RESTRAINTS PERSONAL GEAR, ETC. LIFE SUPPORT CONSUMABLES	205/MAN	{ 3 AT 451	-	-	NONE
		54/MAN	{ 3 AT 488	-	-	
		254/MAN	} CABIN	TBD	-	
		22/MANDAY				
ELECTRICAL POWER KIT	900 KWH FOR PAYLOAD ELECTRICAL POWER	654	{ PAYLOAD BAY 919	926	-	NONE

TABLE 3-2. - PAYLOAD WEIGHT CHARGEABLE ITEM

PAGE 3 OF 3

		POSITION, Meters (Feet)			VELOCITY, Meters/Sec (Feet/Sec)				
NAVIGATION SYSTEM		Altitude	Down-track	Cross-track	Root Sum Square	Altitude	Down-track	Cross-track	Root Sum Square
STEN									
LOCAL (END OF TRACK)	130 (440)	110 (370)	130 (430)	222 (730)	1.2 (3.9)	0.15 (0.5)	0.6 (2.0)	1.3 (4.4)	
PROPOGATED ONE REV.	150 (476)	260 (850)	130 (430)	315 (1030)	1.3 (4.3)	0.15 (0.5)	0.6 (2.0)	1.4 (4.8)	
TLES									
LOCAL (END OF TRACK)	90 (300)	430 (1400)	460 (1520)	630 (2070)	0.5 (1.6)	0.11 (0.35)	0.15 (0.5)	0.5 (1.7)	
PROPOGATED ONE REV.	90 (300)	610 (2010)	460 (1520)	740 (2400)	0.7 (2.4)	0.1 (0.3)	0.15 (0.5)	0.7 (2.5)	

TABLE 3-3 Expected On-Orbit Navigation Accuracies (3 sigma) for 100 n.mi. Orbital Altitude

ORBITAL ALTITUDE			
	<u>100 N.MI.</u>	<u>200 N.MI.</u>	<u>300 N.MI.</u>
	-----DEG-----		
•Local Vertical			
•STCN	0.16	0.16	0.16
•TDES	0.16	0.16	0.16
•Earth Target			
•Locking Vertical			
•STDN	0.18	0.16	0.16
•TDRS	0.28	0.20	0.18
•Locking 30° Off Vertical			
•STDN	0.20	0.17	0.16
•TDRS	0.29	0.20	0.18

TABLE 3-4 Payload Pointing Errors for Earth Targets

Orientation	Fuel Usage, lbs/orbit		
	100 n.mi. Crbit	200 n.mi. Crbit	500 n.mi. Orbit
Y-POP, Z-local Vertical	0.3	0.3	0.3
Y-POP Inertial	3.4	2.3	2.1
Z-POP Inertial	12.8	3.0	2.6
X-POP Inertial	11.0	.6	.5

TABLE 3-5.- EFFECT OF ORBITAL ALTITUDE ON RCS VERNIER FUEL
USAGE FOR PAYLOAD ECINTING WITH VARIOUS ORBITER
ORIENTATIONS

Maneuver Rate, Deg/Sec	Fuel, Lbs			
	Roll	Pitch	Yaw	Total
0.25	3.8	8.0	10.5	22.3
0.5	9.0	11.6	15.0	35.6
0.75	13.0	16.0	29.2	58.2
1.0	16.7	26.6	43.4	86.7

**TABLE 3-6.- FUEL USAGE FOR ORBITER SEQUENTIAL THREE-AXIS
AUTOMATIC MANEUVERS AS A FUNCTION OF
MANEUVER RATE**

PARAMETER	TARGET TYPE	
	COOPERATIVE	PASSIVE
RANGE	560 KM TO 30 M	45 KM TO 30 M
RANGE RATE	FROM + 450 M/SEC TO ZERO	FROM + 150 M/SEC TO ZERO
LOS ANGLE (TWO AXES)		
(1) 560 KM TO 45 KM	+ 5 DEG	+ 5 DEG
(2) 45 KM TO 30 M	+ 5 DEG	+ 5 DEG
LOS ANGLE RATE (TWO AXES)		
FROM 45 KM TO 30 M		
(1) ACQUISITION	+ 4 MR/SEC	+ 4 MR/SEC
(2) TRACKING	+ 5 DEG/SEC	+ 5 DEG/SEC

TABLE 3.7 - RENDEZVOUS LIMITS

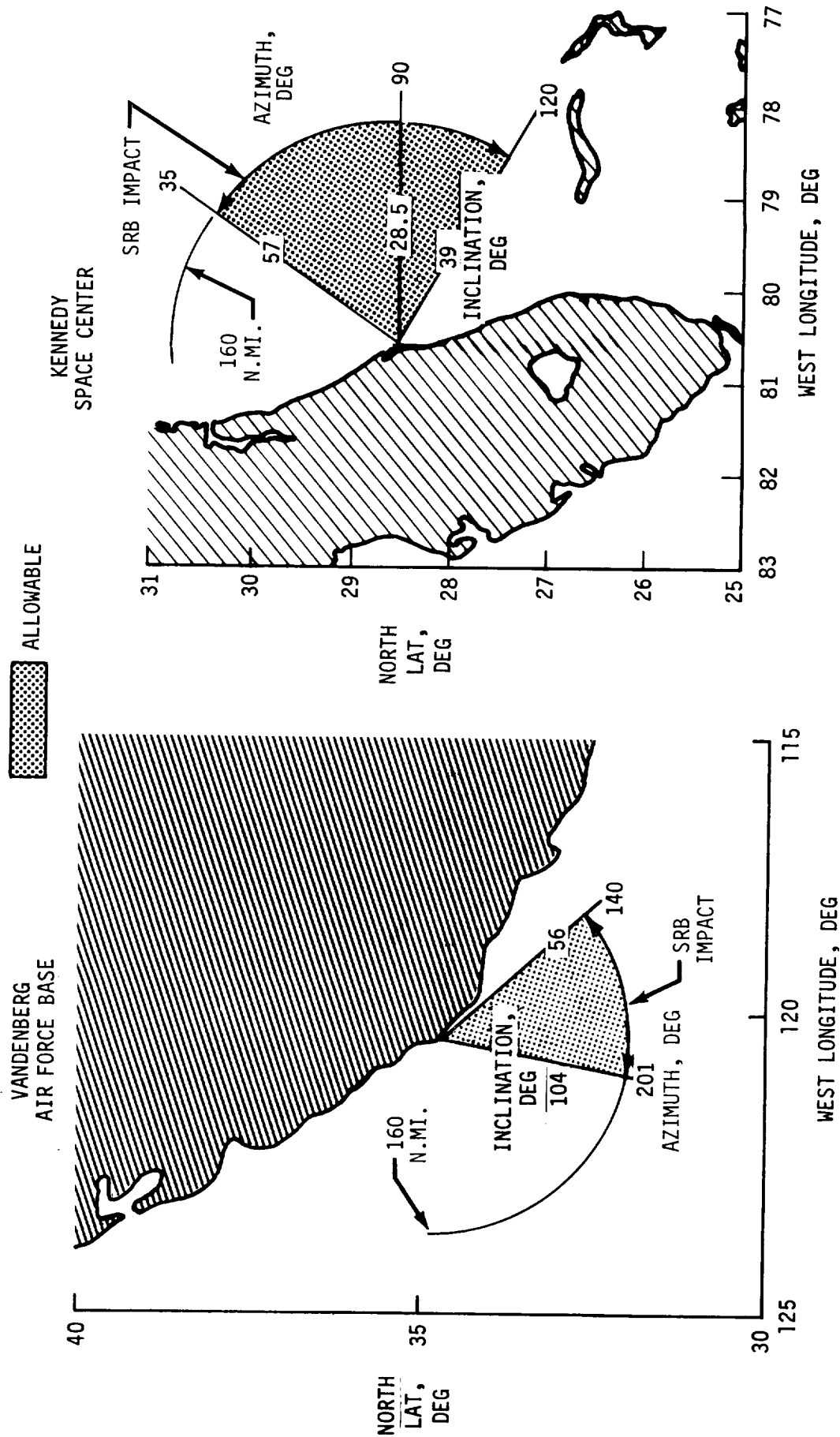


FIGURE 3-1. LAUNCH AZIMUTH AND INCLINATION LIMITS FROM VAFB AND KSC

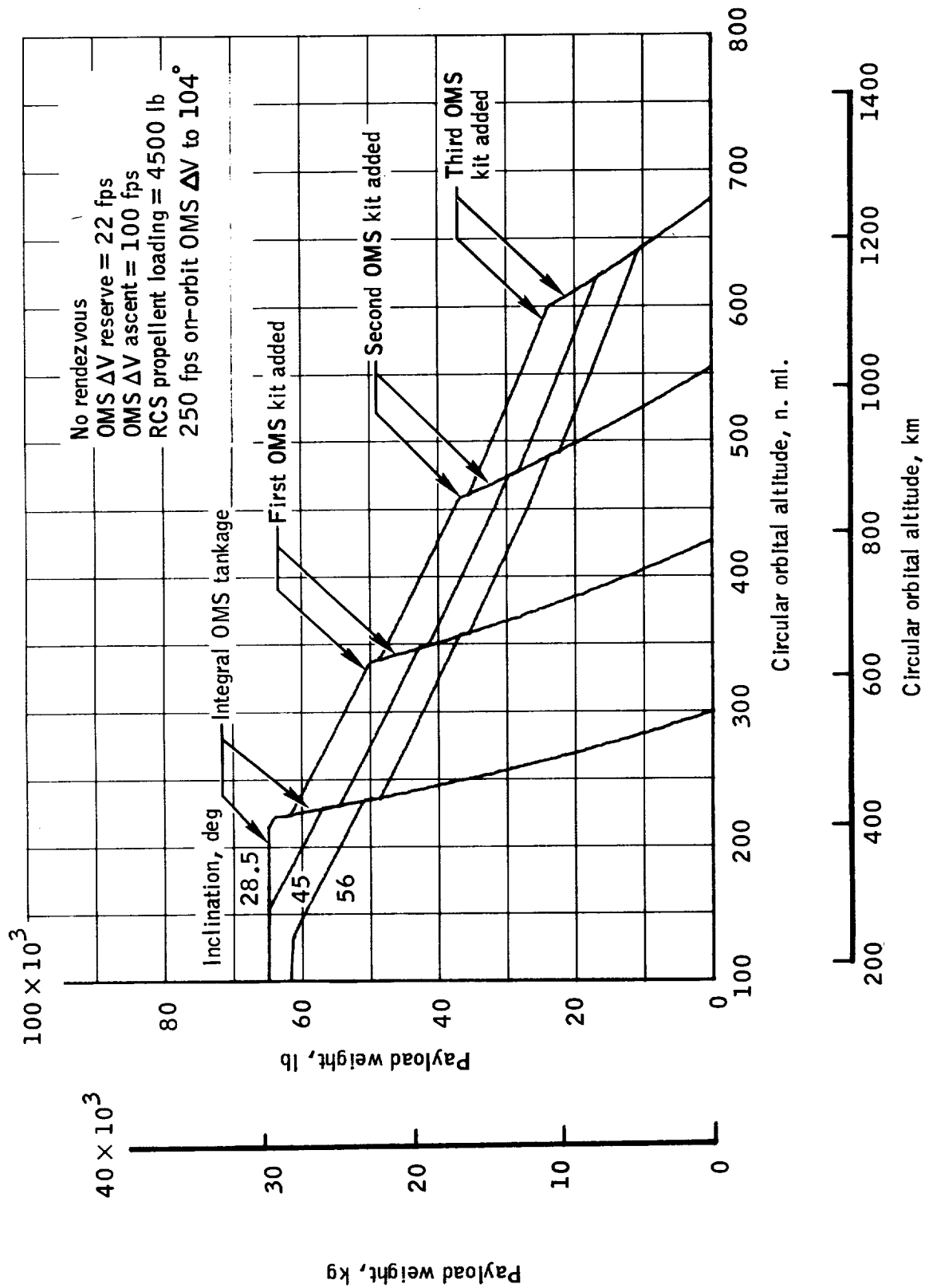


Figure 3-2.- Payload weight versus circular orbital altitude - KSC launch, delivery only.

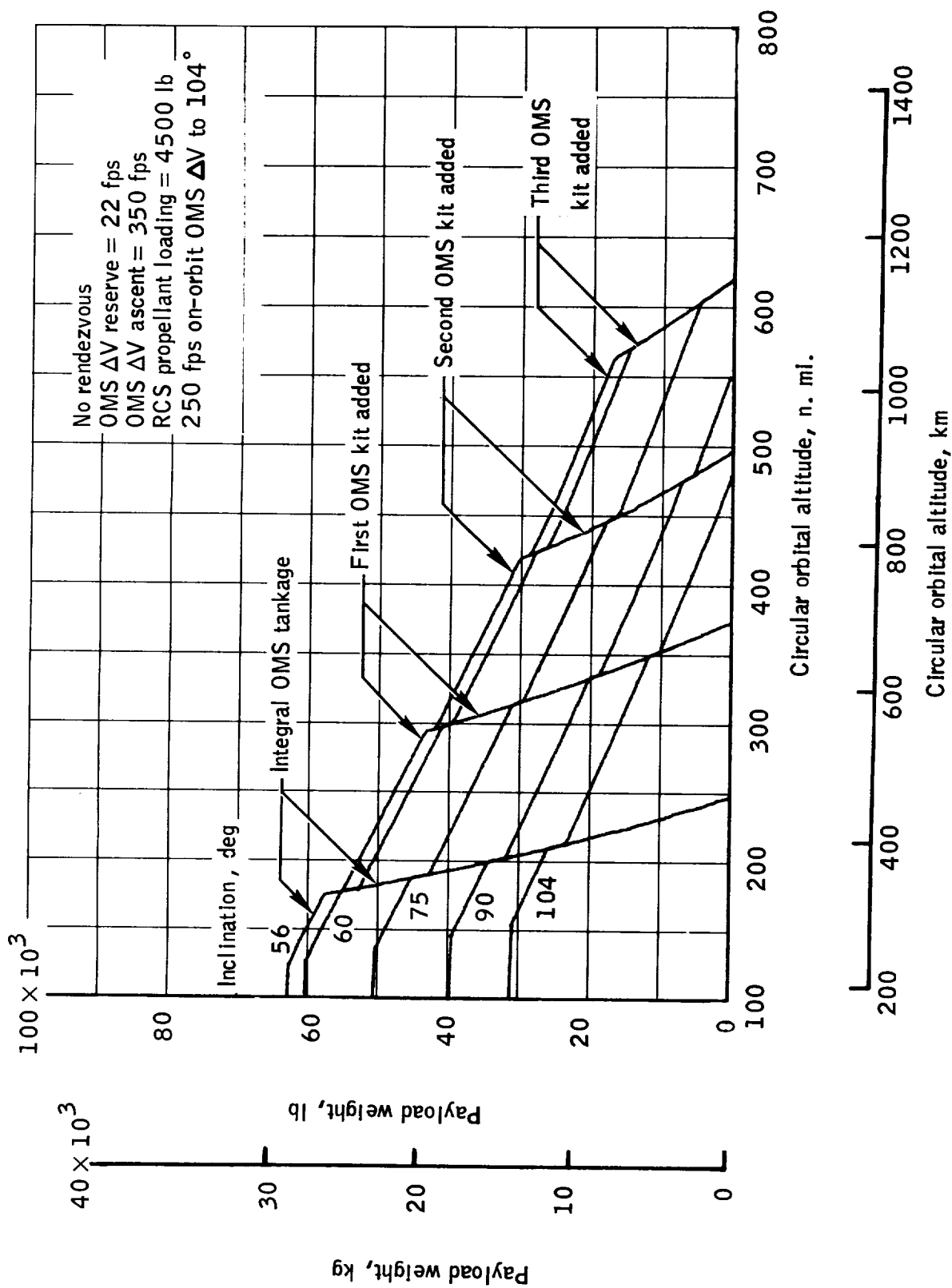


Figure 3-3.- Payload weight versus circular orbital altitude - VAFB launch, delivery only.

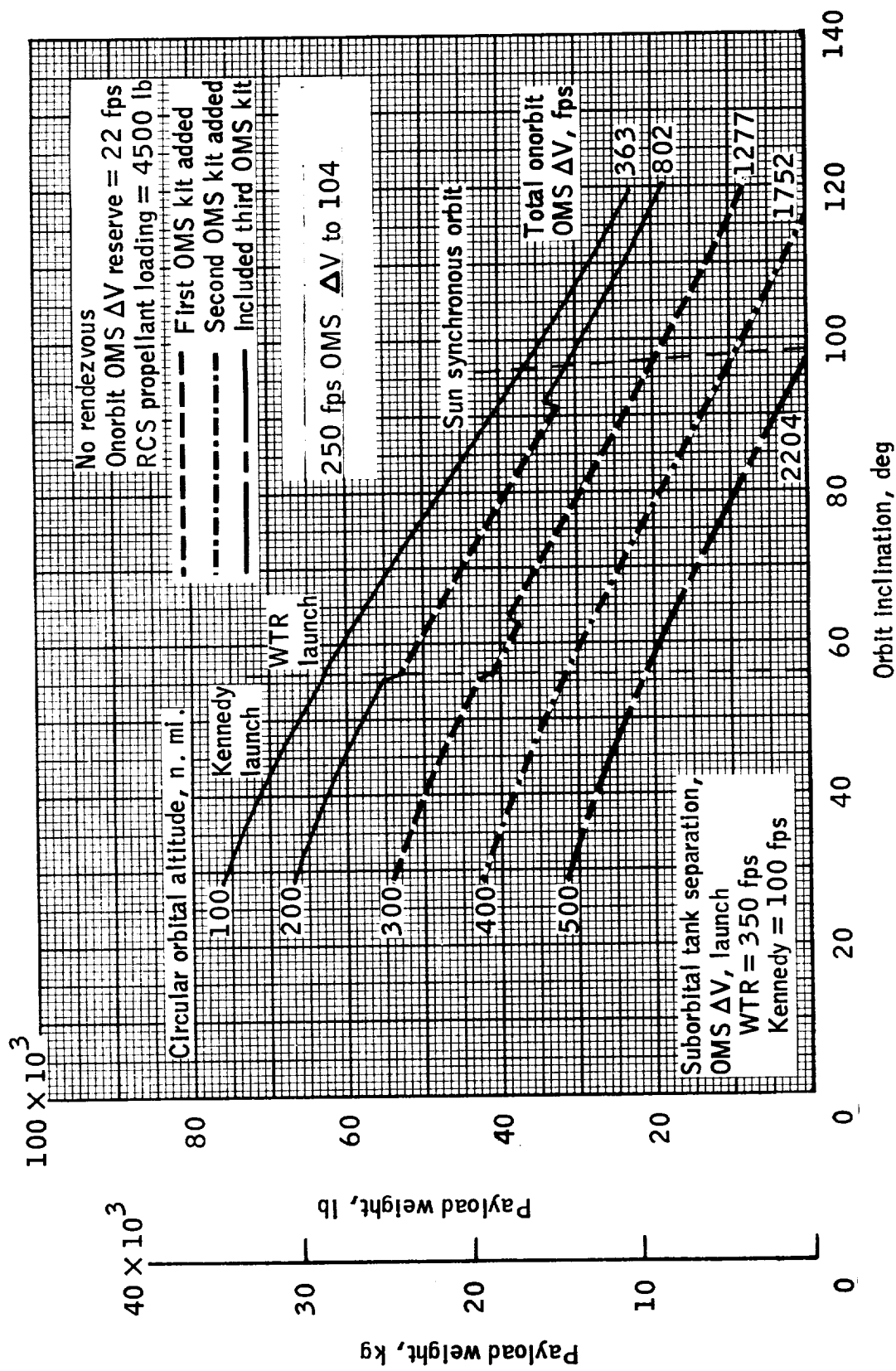


Figure 3-4 .- Payload weight versus inclination for various circular orbital altitudes - delivery only.

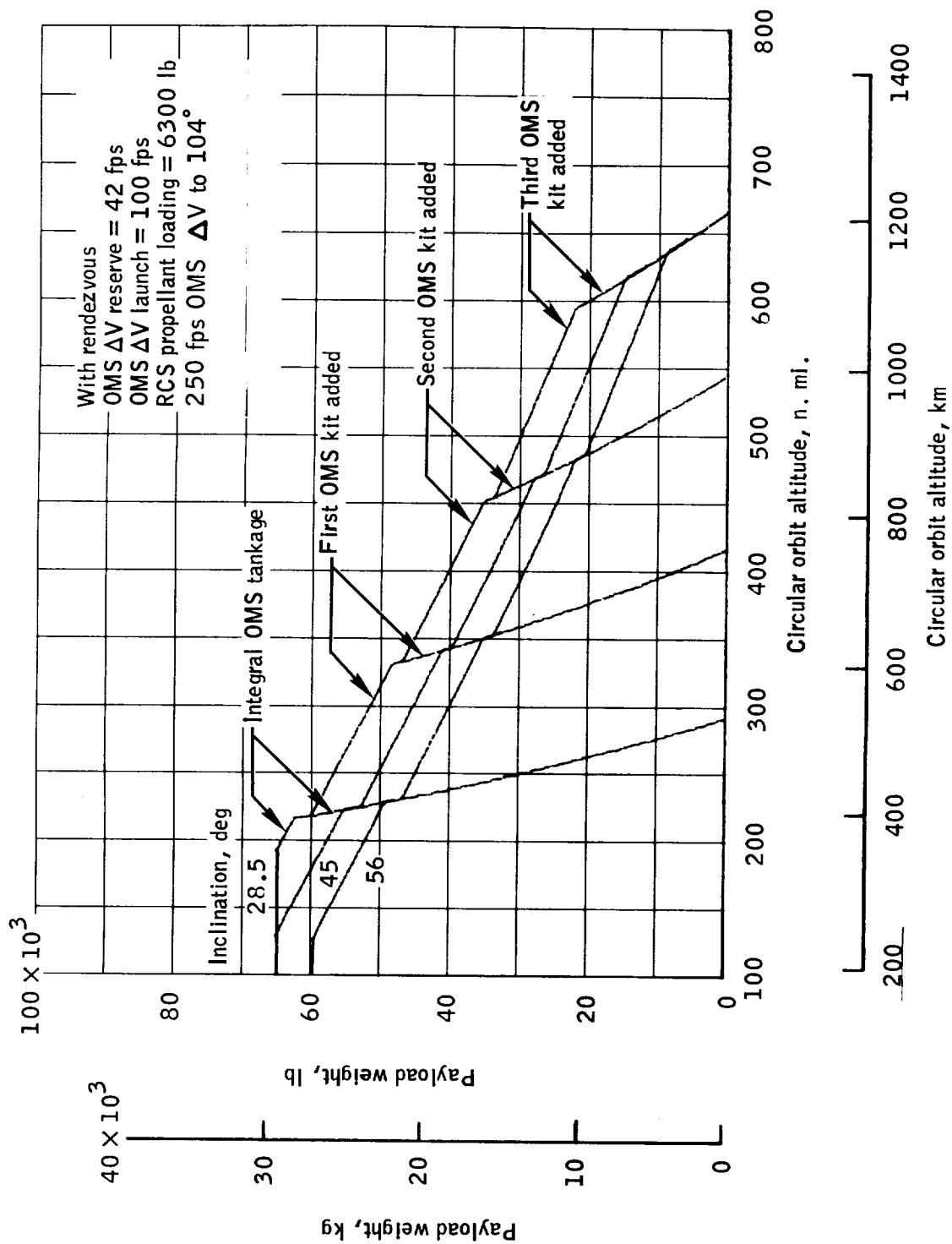


Figure 3-5 .- Payload weight versus circular orbital altitude - KSC launch, delivery and rendezvous.
 3-21

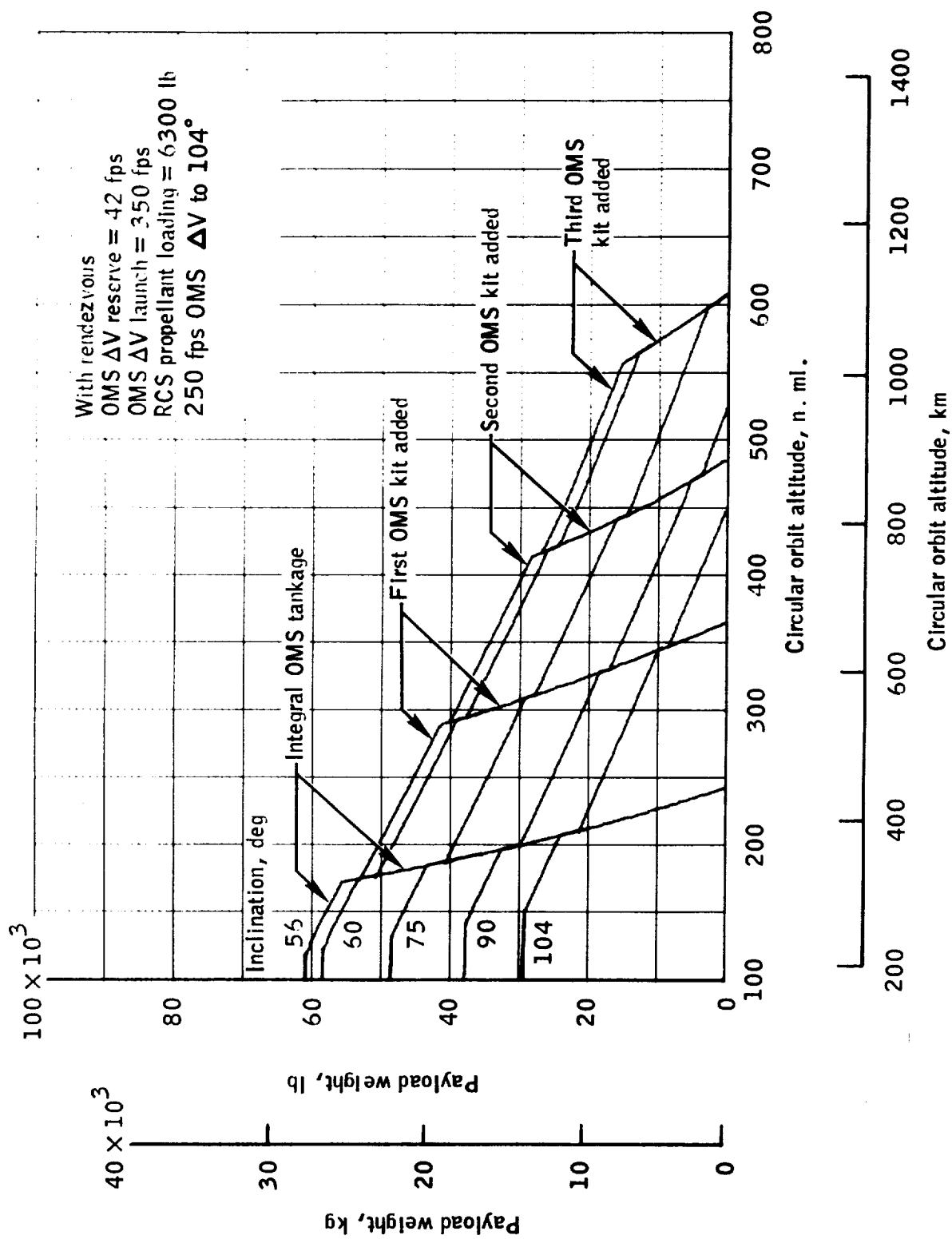


Figure 3-6 .- Payload weight versus circular orbital attitude - VAFB launch, delivery and rendezvous.

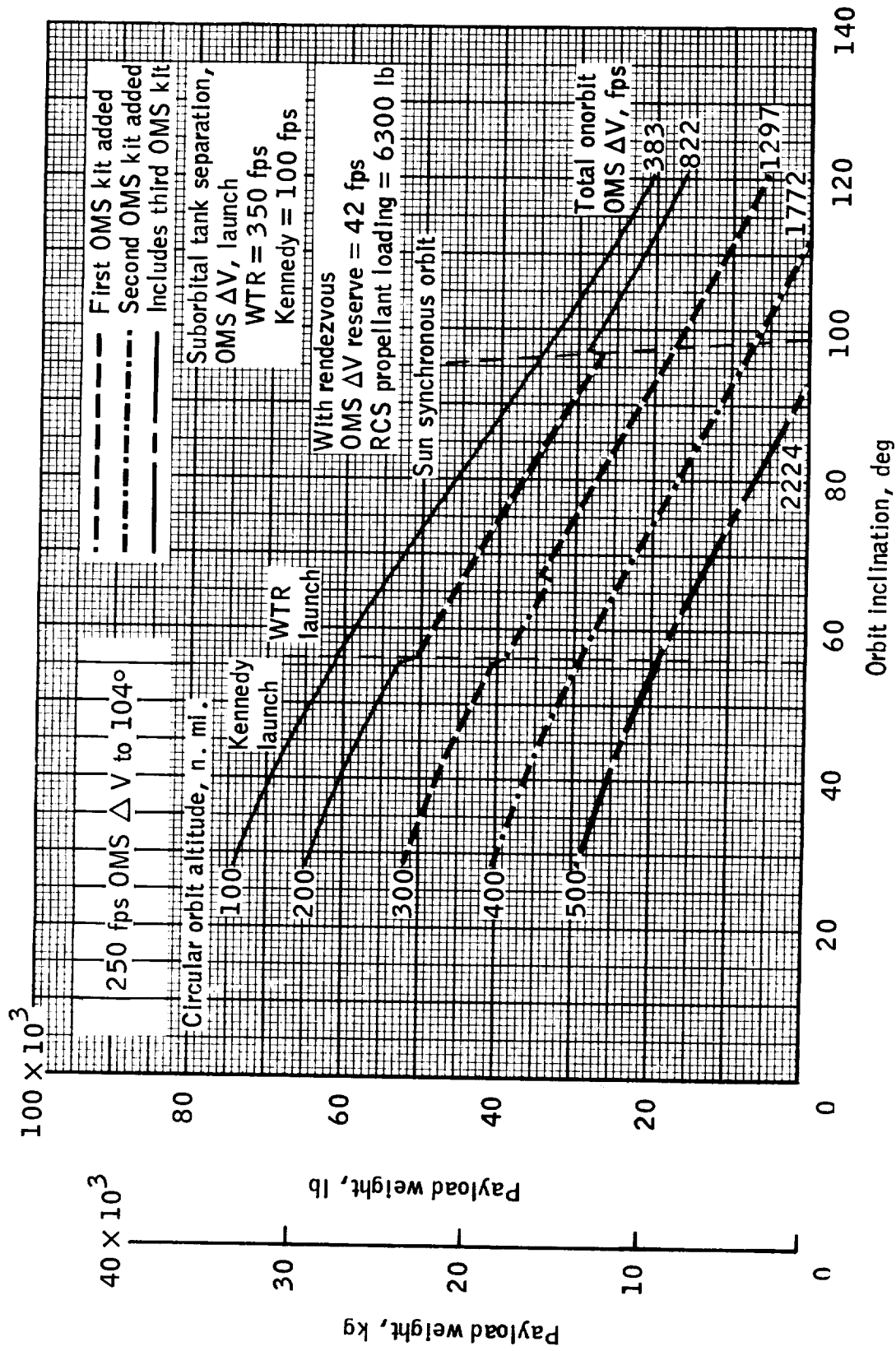


Figure 3-7 .- Payload weight versus inclination for various circular orbital altitudes - delivery and rendezvous.

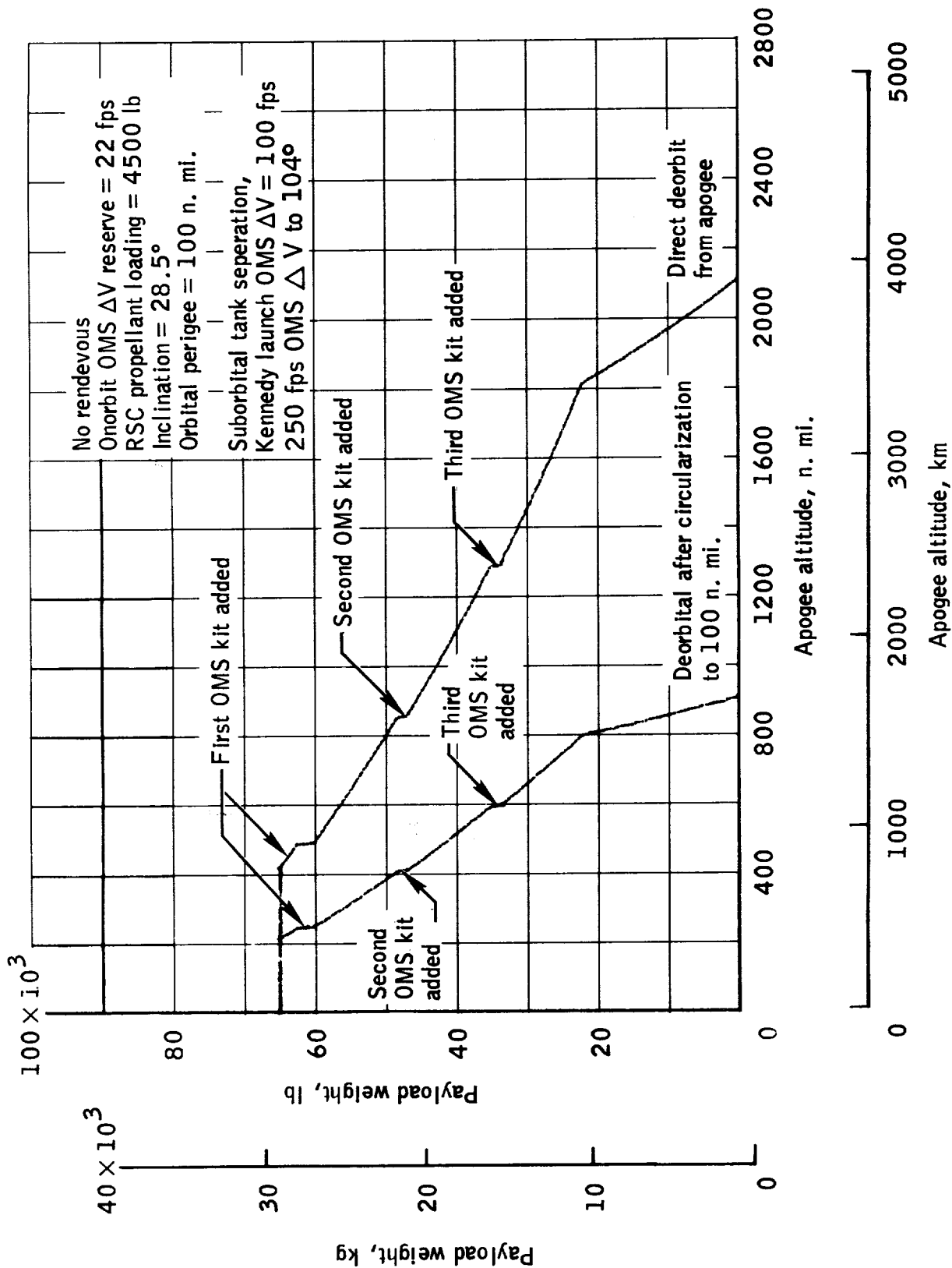


Figure 3-8 - Payload weight versus elliptical orbital altitude.

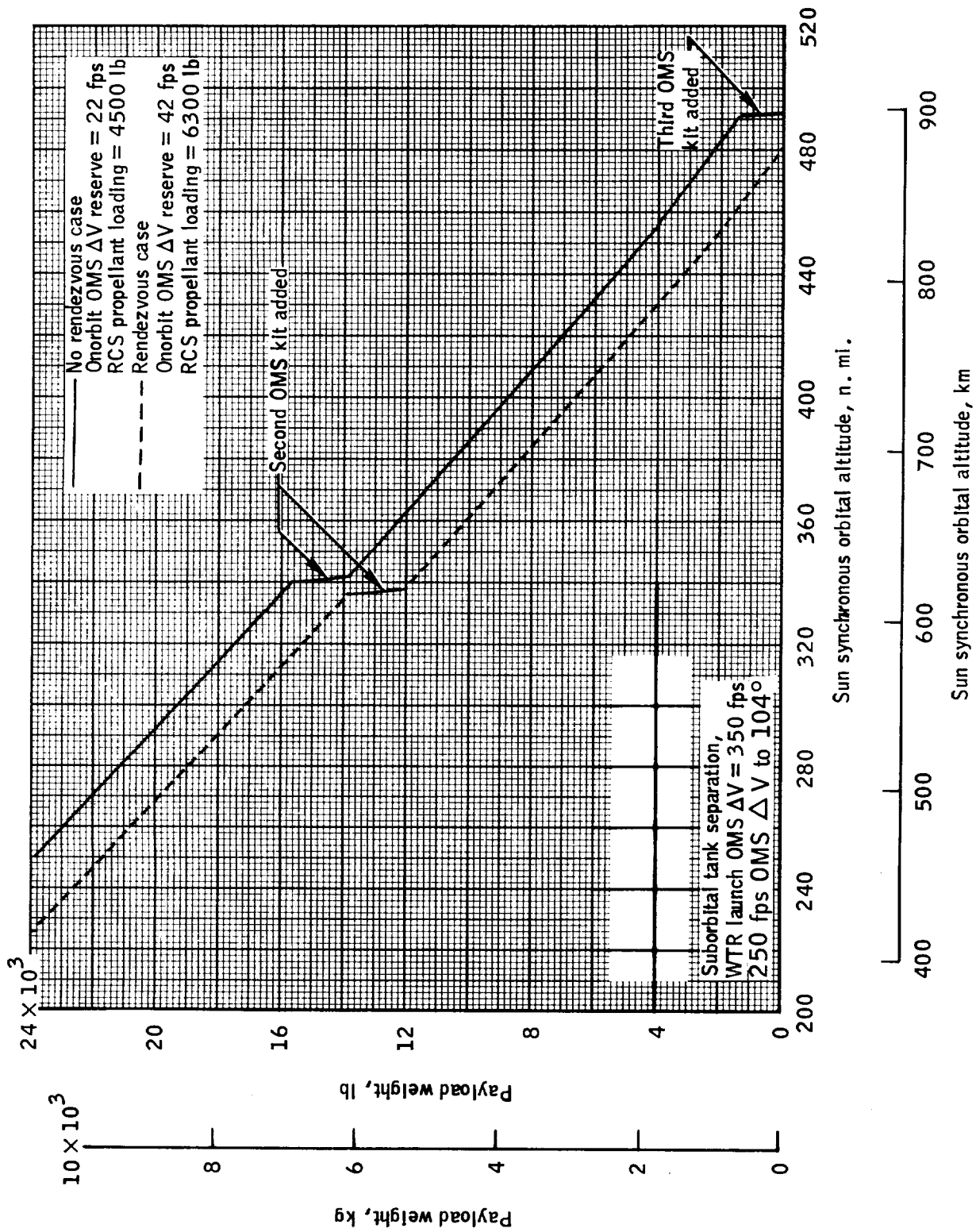


Figure 3-9.- Payload weight versus sun synchronous orbital altitude.

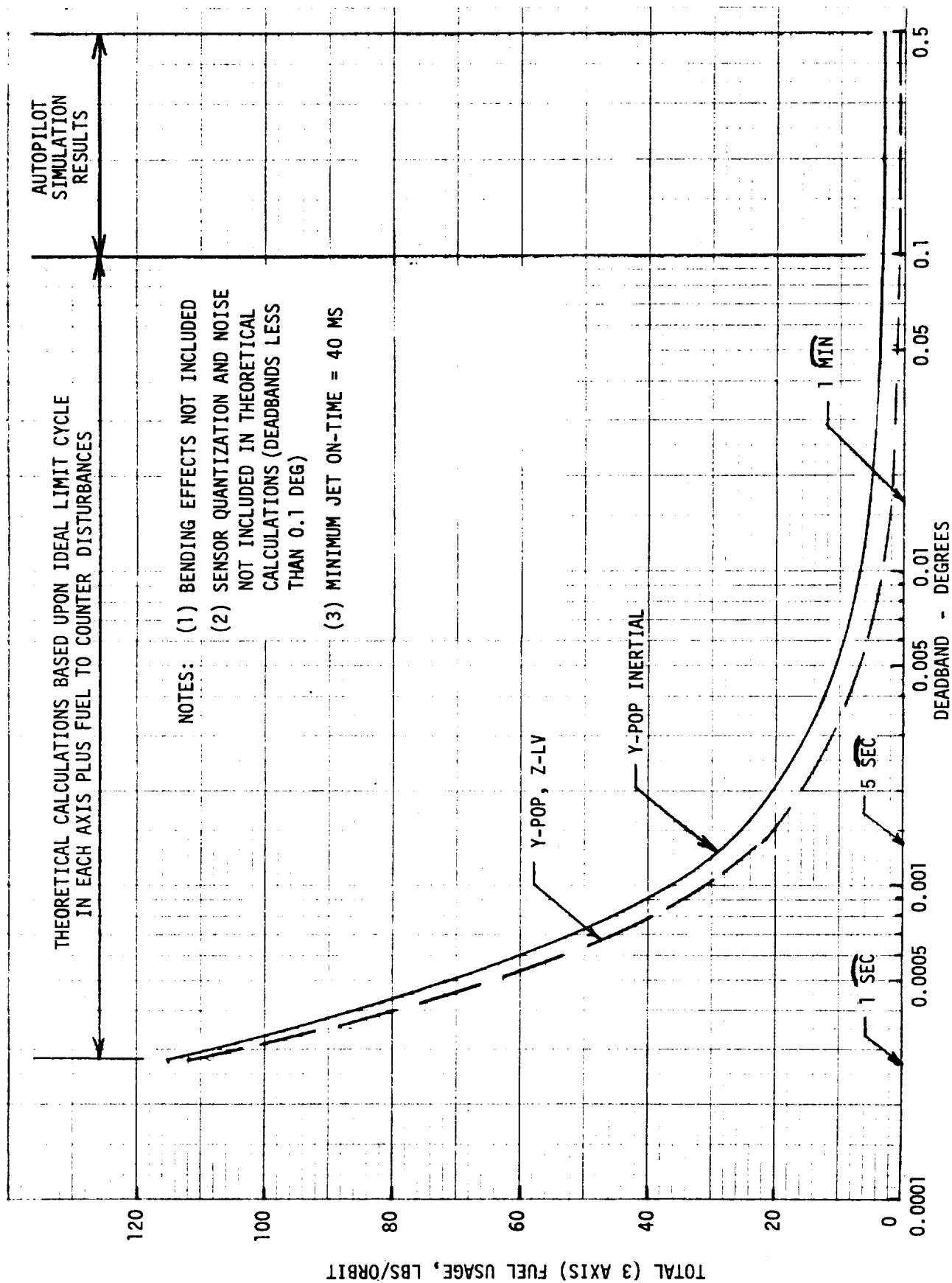
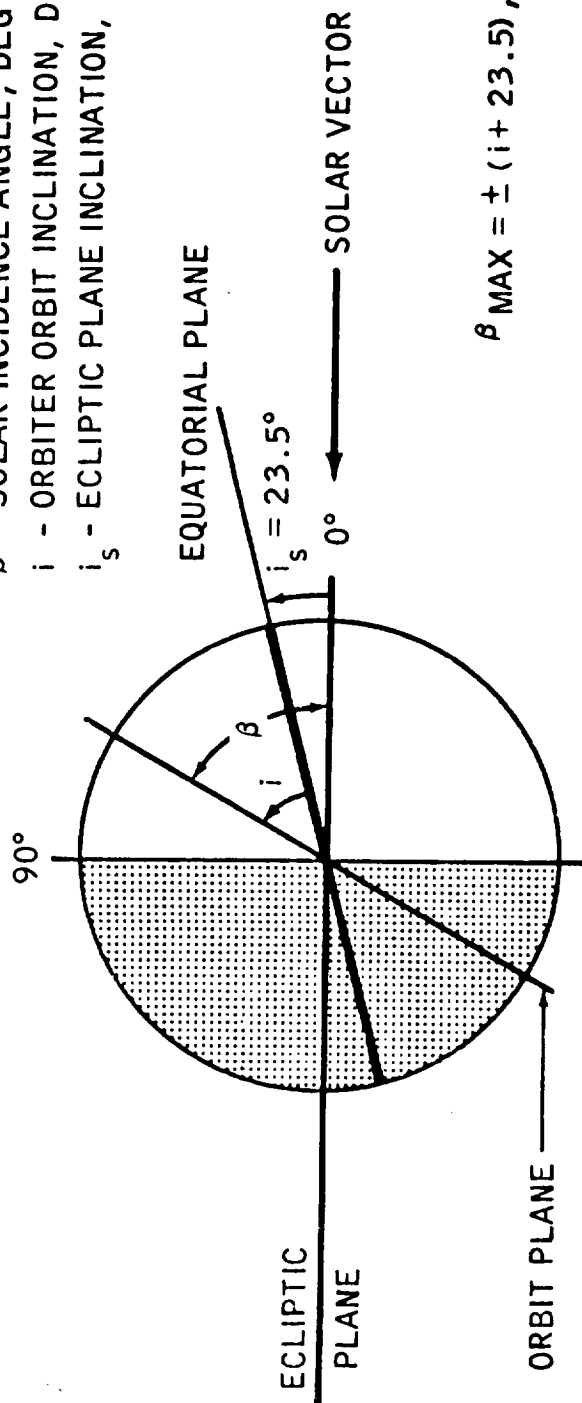


FIGURE 3-10. - EFFECT OF ATTITUDE DEADBAND ON ORBITER FUEL USAGE FOR PAYLOAD POINTING
IN TYPICAL LOCAL VERTICAL AND INERTIAL ORIENTATIONS

β - SOLAR INCIDENCE ANGLE, DEG
 i - ORBITER ORBIT INCLINATION, DEG
 i_s - ECLIPTIC PLANE INCLINATION, DEG



$$\beta_{\text{MAX}} = \pm (i + 23.5), \text{DEG.}$$

β RANGE DEGREES	ORBITER ORIENTATION	HOLD CAPABILITY HOURS	PREENTRY THERMAL CONDITIONING REQUIREMENTS HOURS
0 TO 60	ANY	≥ 160	≤ 12
60 TO 90	A. OTHER THAN INERTIAL HOLDS	CYCLES OF 6-HOUR HOLDS FOLLOWED BY 3 HOURS OF THERMAL CONDITIONING FOR WORST THERMAL ATTITUDES	≤ 7
	B. 3-AXIS INERTIAL HOLDS	≥ 160	≤ 12

FIGURE 3-11. - ORBITER THERMAL ATTITUDE CONSTRAINTS

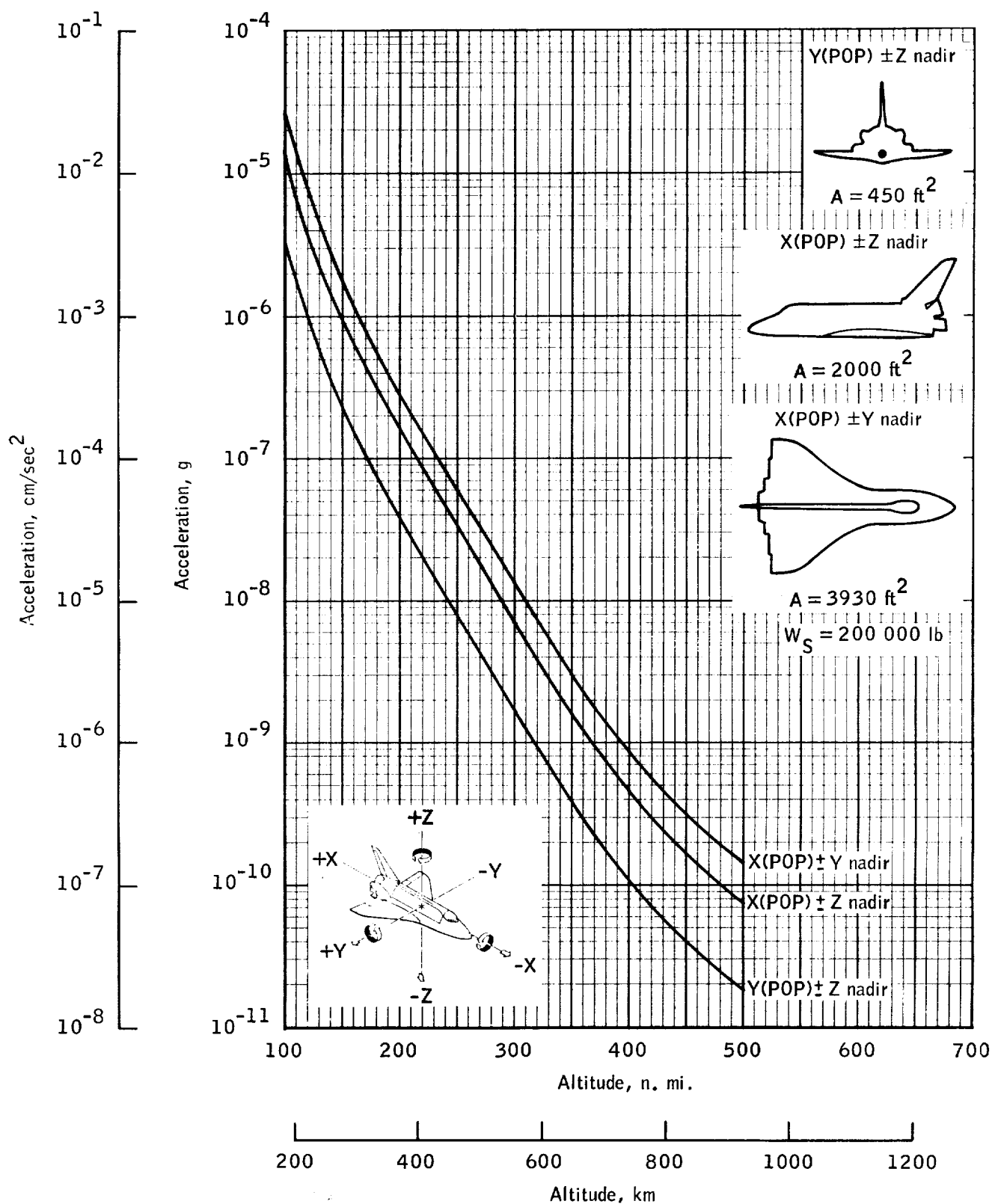


FIGURE 3-12. EFFECTS OF ATMOSPHERIC DRAG ON THE ORBITER

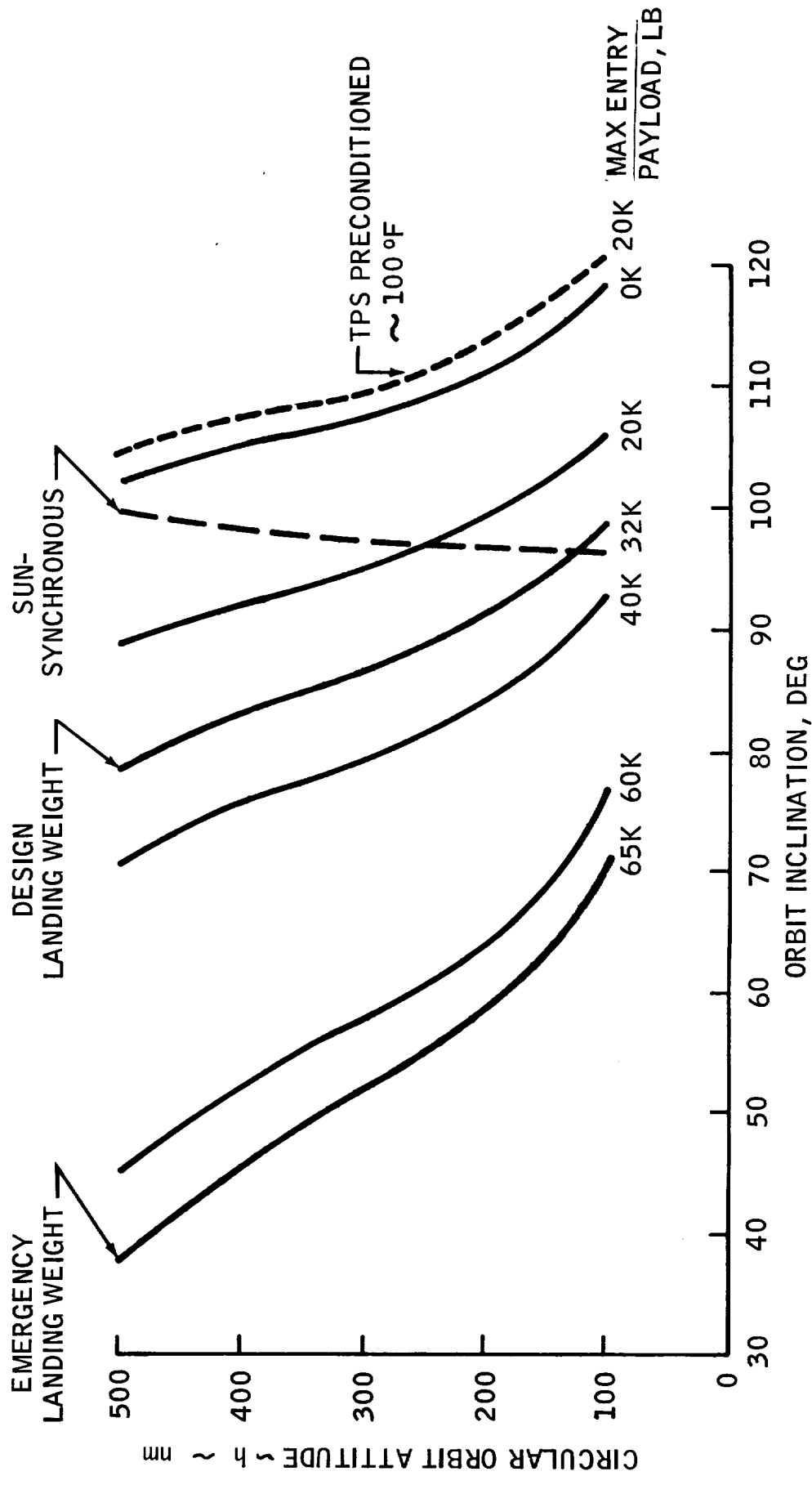


FIGURE 3-13. - PRELIMINARY DIRECT REENTRY CAPABILITY

This page intentionally left blank.

4.0 STRUCTURAL/MECHANICAL

4.1 Payload Bay. A 15 feet in diameter by 60 feet long payload envelope is provided. This volume is the maximum allowable payload dynamic envelope. This envelope is penetrated by the necessary payload structural attachments and umbilicals which extend outside the envelope to interface with the Orbiter. Clearance between the payload envelope and the Orbiter structure is provided by the Orbiter to prevent Orbiter deflection and deployment interference between the Orbiter and the payload envelope. Similarly, the payload must remain within the 15 feet in diameter by 60 feet long envelope including its deflections.

The Orbiter has the capability of exposing the entire length and full width of the payload bay doors. With the payload bay doors and radiators open, the Orbiter provides an unobstructed 180 degree lateral field of view, except for localized interference due to the manipulator supports and the door hinges, for any point along the line $Y_0 = 0$, $Z_0 = 427$ between $X_0 = 582$ and $X_0 = 1302$. From the mid-point of the payload envelope ($X_0 = 942$, $Y_0 = 0$, $Z_0 = 400$), the following clearance angles, measured from the Z axis toward the X axis, are maintained:

To the forward bulkhead	- 75°
To the aft bulkhead	- 74°
To the vertical stabilizer	- 57°

The coordinate systems established for the Orbiter and payloads are shown in Figure 4-1 and 4-2.

4.2 Payload Structural Attachments. Payload structural accommodations provides thirteen (13) attachments, ten (10) which are evenly spaced 59 inches apart as shown in Figure 4-3. With the exception of the aft position, each attachment consists of three attachment points, one on each longeron ($Z_0 = 414$, $Y_0 = \pm 94$), and one at the keel ($Z_0 = 306$, $Y_0 = 0$). Each set of three points define a plane normal to the payload bay centerline. The aft attachment consists of attachment points on the two longerons ($X_0 = 1293$, $Y_0 = \pm 94$, $Z_0 = 414$) but none at the keel; this attachment is provided to accommodate the initial upper stage if required and the future space tug. This design provides flexibility for accommodating a wide spectrum of payloads. The fittings along the mid-fuselage longeron are capable of reacting loads in the $\pm X$ and $\pm Z$ or the $\pm Z$ directions; while the lower keel fittings react loads in the $\pm Y$ direction only. A four-point retention concept,

no 3-30
4-1

as shown in Figure 4-4 provides a statically determinate mounting. Once the Orbiter and payload stiffness characteristics are defined, further versatility in retention concepts may be possible. Table 4-1 summarizes the payload bay limit load factors. The load carrying capability of the support points in each direction is TBD. Adapters, cradles, or pallets may be used to facilitate mounting of payload items but must be included as payload weight chargeable items.

Figures 4-5, 4-6, and 4-7 illustrate the Orbiter's longitudinal, vertical and lateral allowable payload c.g. envelope.

4.3 Payload Deployment/Retrieval Mechanism. The deployment and retrieval of payloads is accomplished by using the general purpose remote manipulator system (RMS) illustrated in Figure 4-8. Table 4-2 lists some basic characteristics of the RMS. One manipulator arm is provided by the Orbiter and may be mounted on either the left or right longeron. If a particular payload requires the use of two manipulator arms, the weight of the second manipulator arm is a payload weight chargeable item. The manipulator arm is mounted at station Xo 680 and has a maximum reach from that point of 52 feet. Figure 4-9 illustrates the reach capability of the RMS at various vertical stations in the payload bay. If deployed payloads which remain attached to the Orbiter require more precise alignment than can be furnished by the RMS, the necessary devices must be provided as part of the payload.

A payload is retrieved in three basic steps: (1) transmission of commands to the payload for stabilization, orientation for manipulator attachment, retracting solar arrays, antenna, etc.; (2) manipulator engagement, translation, and securing in the payload bay; and (3) connection of payload utilities, e.g., caution/warning, power, data, and fluid/gas venting when required.

4.4 Airlock and Payload Bay Hatch. The airlock is located on the lower level of the Orbiter cabin and has a payload bay hatch which is located on the vertical centerline at $Z_0 = 366$ with a 40-inch diameter opening into the payload bay. Use of the airlock will permit either EVA or transfer to and from a habitable payload. To accomplish EVA, approximately four feet of unobstructed payload bay length is required next to the payload bay hatch such that

the hatch may be opened and a suited crewman can egress. The size of the airlock and associated hatches limits the external dimensions of packages that can be transferred to or from payloads to 22 x 22 x 50 inches for unsuited operations and 18 x 18 x 50 inches for pressurized suit operations.

4.5 Docking Module. The Orbiter may be docked to another orbital element by using a docking module installed in the payload bay. This module is attached to the Orbiter airlock with access provided by the payload bay hatch. The docking mechanism is extended above the Orbiter mcd line to permit engagement to another orbital element docking mechanism. A 40-inch clear diameter passageway is provided through the docking module, either to the payload bay or to an attached habitable payload. Typical installation is shown in Figures 4-10 and 4-11. EVA is possible with either configuration, with access to the exterior through the docking interface hatch. The size object that can be moved to or from the habitable payload by an unsuited crewman is 22 x 22 x 50 inches and 18 x 18 x 50 inches for EVA suited operations to or from the payload bay.

The docking module is the primary mode for on-orbit rescue of the crew from a disabled Orbiter. The docking module is either carried as part of the payload or is brought up and emplaced by the rescue vehicle. The ground rules concerning the use of the docking module are currently under review.

4.6 Service Panels. Ground services required by the payload after installation in the Orbiter such as electrical power, fluids and gases, filling, venting, draining, etc., will be provided through service panels located on the Orbiter and may be independent of Orbiter systems. The ground services required shall be assigned to either the Pre-flight or launch umbilical panels in accordance with the following criteria:

a. Ground services required to preclude a hazardous condition or to save the payload, in the event a launch abort is required subsequent to T-30 minutes, shall be assigned to the launch umbilical panel (T-0 umbilicals) located at the aft end of the Orbiter.

b. Fluid services compatible with fuels shall be assigned to the launch umbilical fuel panel (-Y side of the Orbiter). Fluid services compatible with oxidizers shall be assigned to the launch umbilical oxidizer panel (Y side of the Orbiter).

c. Ground services required up to T-30 minutes shall be assigned to the Pre-flight panel which is located on the -Y side of the Orbiter at station TED. Figures 4-12, 4-13, and 4-14 show the launch umbilical fuel, launch umbilical oxidizer and ground service panels respectively.

Standardized payload utility services from the Orbiter subsystems are provided at the payload bay hatch and on the forward bulkhead of the payload bay exterior to the 40 inch hatch clearance opening. The interfaces provided at the hatch include redundant caution/warning, data, power, communication, and fluid interface connectors. These connectors may be engaged or disengaged without EVA when a pressurized payload is connected to the payload bay hatch.

Figures 4-15 and 4-16 illustrate the locations of utilities and their details at station X_Q = 576 on the forward payload bay bulkhead. Figures 4-17 and 4-18 show the locations of utilities and their details at station X_Q = 1307 on the aft payload bay bulkhead.

CONDITION*	Xo	Yo	Zo
Lift-off***	-1.7±0.6	±0.3	-0.8 -0.2
High Q Boost	-1.9	±0.2	+0.2 -0.5
Escster End Burn	-3.0±0.3	±0.2	-0.4
Orbiter End Burn	-3.0±0.3	±0.2	-0.5
Space Operations	-0.2 +0.1	±0.1	±0.1
Entry	±0.25	±0.5	+3.0 -1.0
Subsonic Maneuvering	±0.25	±0.5	+2.5 -1.0
Landing and Braking	±1.5	±1.5	+2.5
Crash**	+9.0 -1.5	±1.5	+4.5 -2.0

*Positive X, Y, Z directions equal aft, right, and up.
Load factor carries the sign of the externally applied load.

**Crash load factors are ultimate and only used to design payload support fittings and payload attachment fasteners. Crash load factors for the nominal payload of 65,000 pounds. Longitudinal load factors are directed in the forward azimuth within 20 degrees of the Orbiter longitudinal axis. The specified load factors shall operate separately.

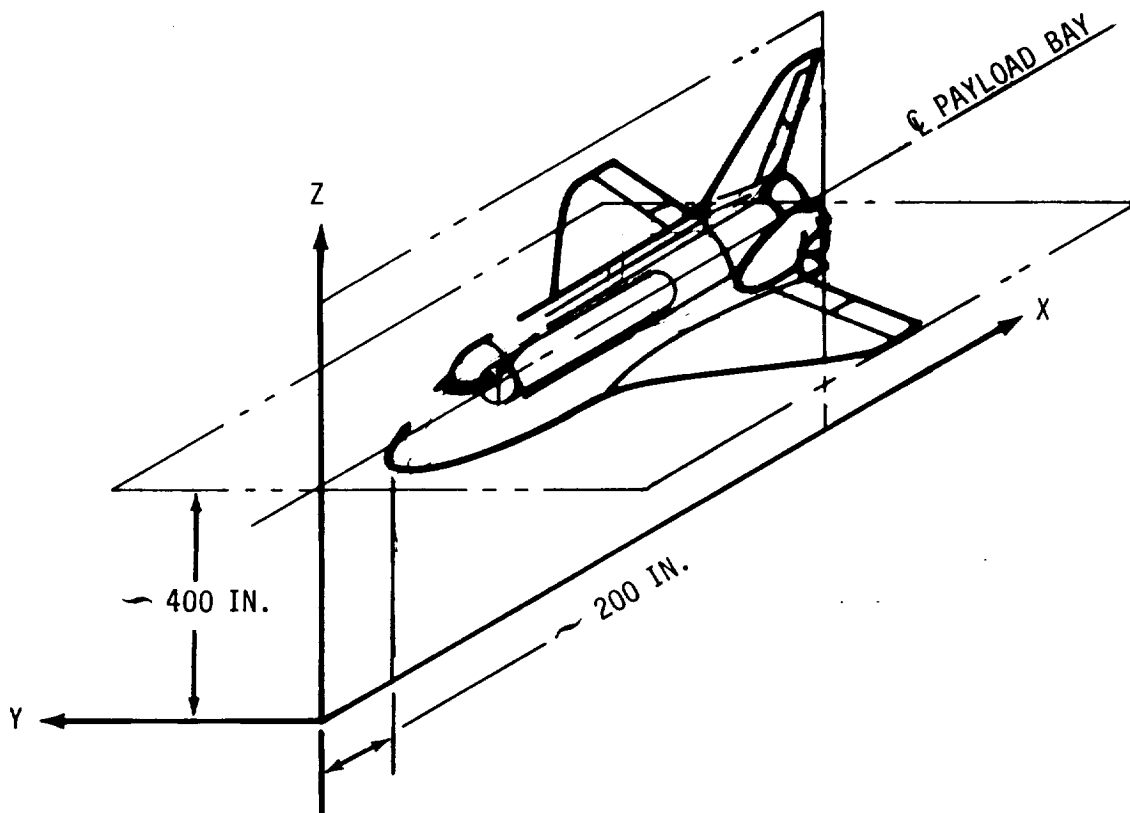
***These factors include dynamic transient load factors at lift-off.

****These factors do not include dynamic response of the payload.

Table 4-1 Payload Bay Limit Load Factors

Operaticnal Mode	RMS Characteristics
Payload deployment	<p>32K payload in less than 7 minutes</p> <p>65K payload in less than 10 minutes</p> <p>Residual rates 1.0 - 2.0 fps and 0.15 deg/sec</p> <p>Up to 5 payloads/mission</p>
Payload retrieval	<p>Stabilized payloads up to 65K</p> <p>Stopping distance:</p> <p>65K payload -- 2.5 feet at a tip speed of 0.2 fps</p> <p>Unloaded tip speed -- 2.0 fps</p> <p>Miss distance -- 2 inches</p>

Table 4-2 Remote Manipulator System (RMS) Characteristics



TYPE: ROTATING, ORBITER REFERENCED

ORIGIN: APPROXIMATELY 200 INCHES AHEAD OF THE NOSE AND APPROXIMATELY 400 INCHES BELOW THE CENTERLINE OF THE PAYLOAD BAY

ORIENTATION AND LABELING:

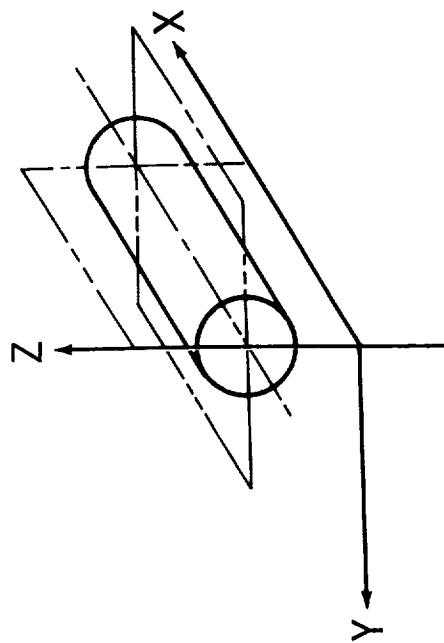
THE X AXIS IS PARALLEL TO THE CENTERLINE OF THE PAYLOAD BAY, NEGATIVE IN THE DIRECTION OF LAUNCH

THE Z AXIS IS POSITIVE UPWARD IN LANDING ATTITUDE

THE Y COMPLETES THE RIGHT-HANDED SYSTEM

THE STANDARD SUBSCRIPT IS 0

FIGURE 4-1.-ORBITER COORDINATE SYSTEM



TYPE: ROTATING, PAYLOAD REFERENCED

ORIGIN: APPROXIMATELY 200 INCHES BELOW THE CENTERLINE OF THE FORWARD END OF THE PAYLOAD

ORIENTATION AND LABELING:

X AXIS IS NEGATIVE IN THE DIRECTION OF LAUNCH, PARALLEL TO THE ORBITER PAYLOAD BAY CENTERLINE

Z AXIS IS POSITIVE UPWARD IN THE ORBITER LANDED POSITION, PARALLEL TO ORBITER Z AXIS

Y AXIS COMPLETES THE RIGHT-HANDED SYSTEM

THE STANDARD SUBSCRIPT IS P

FIGURE 4-2. - PAYLOAD COORDINATE SYSTEM

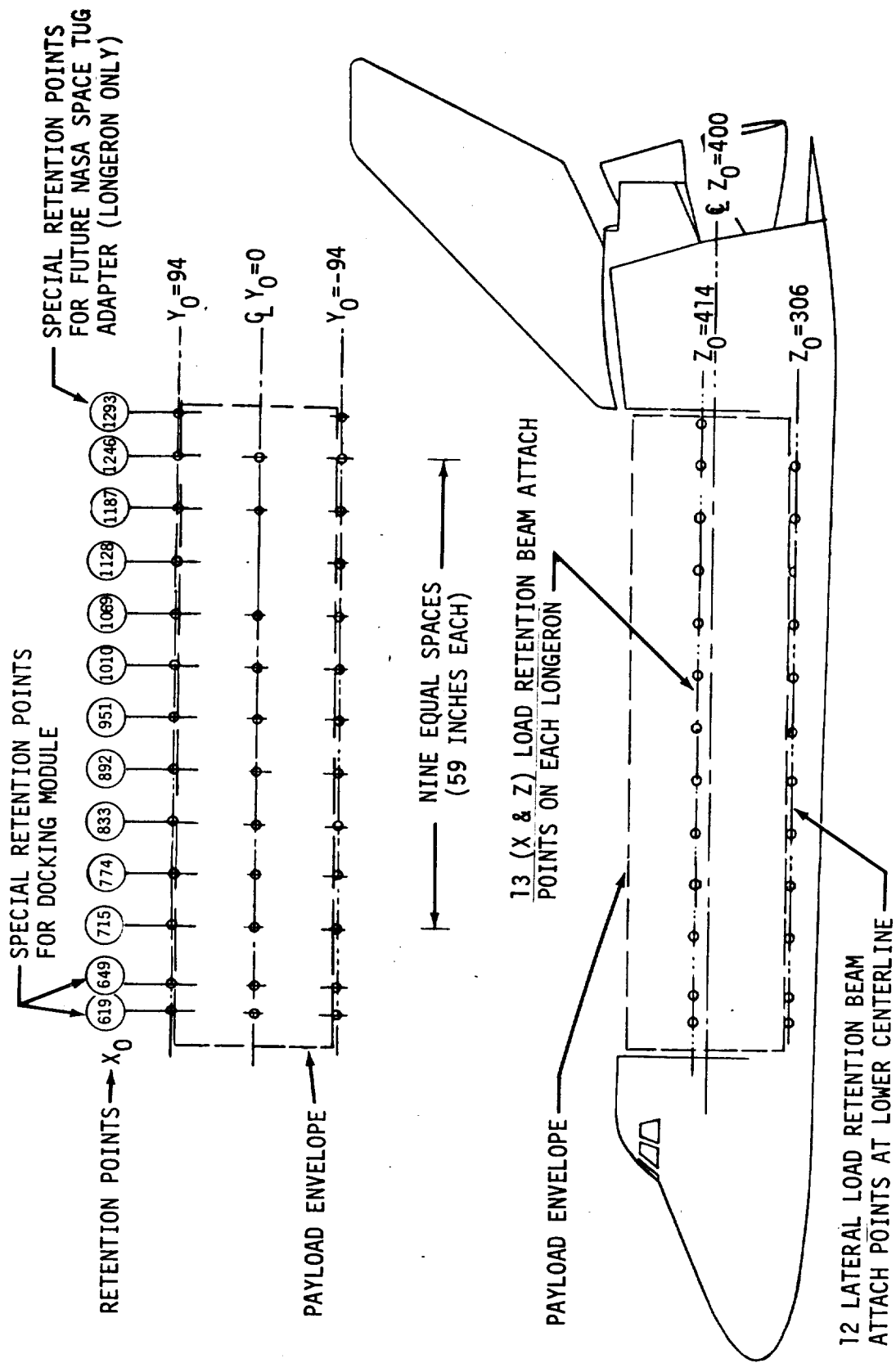


FIGURE 4-3. - PAYLOAD ATTACHMENT LOCATIONS

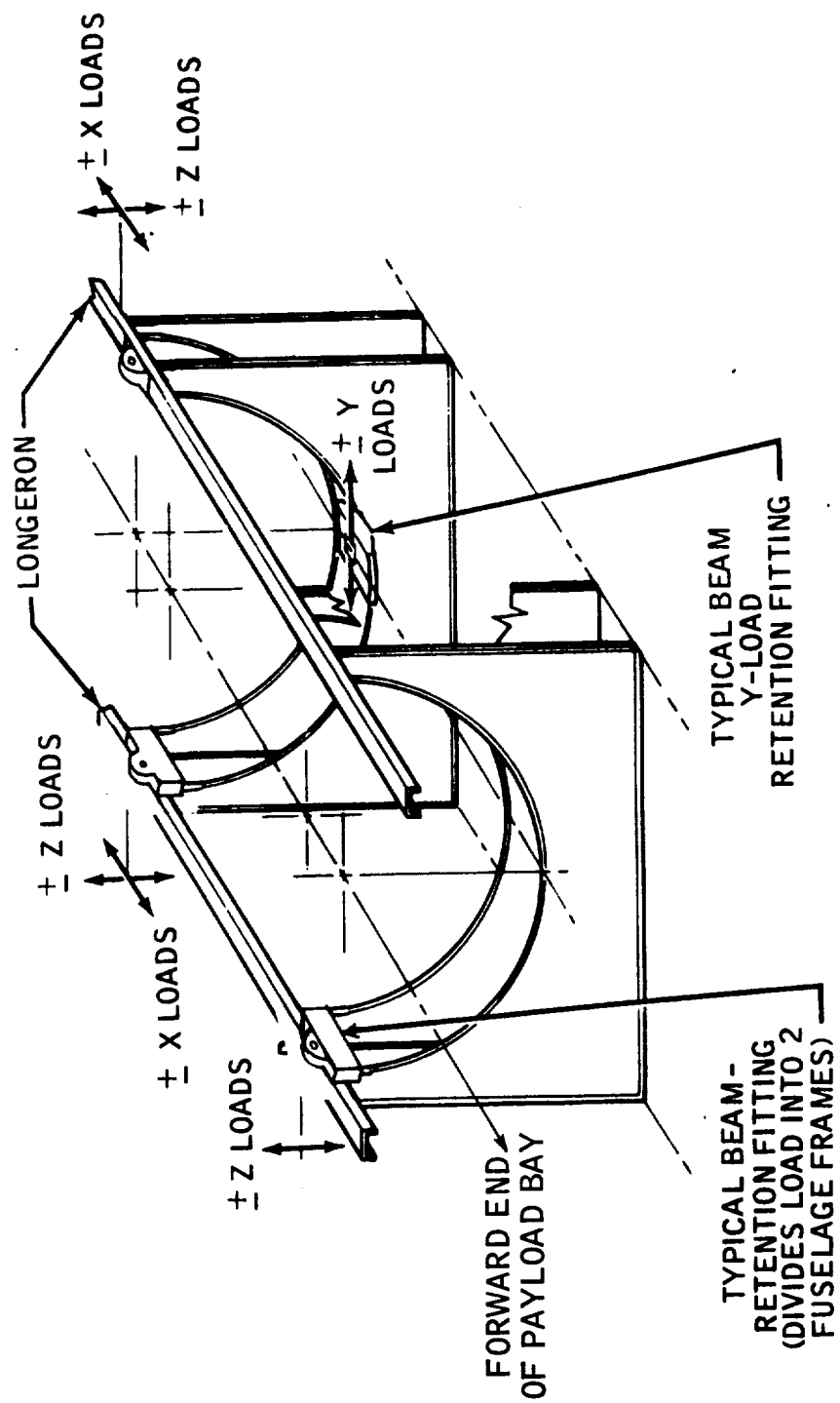


FIGURE 4-4. - PAYLOAD RETENTION SYSTEM

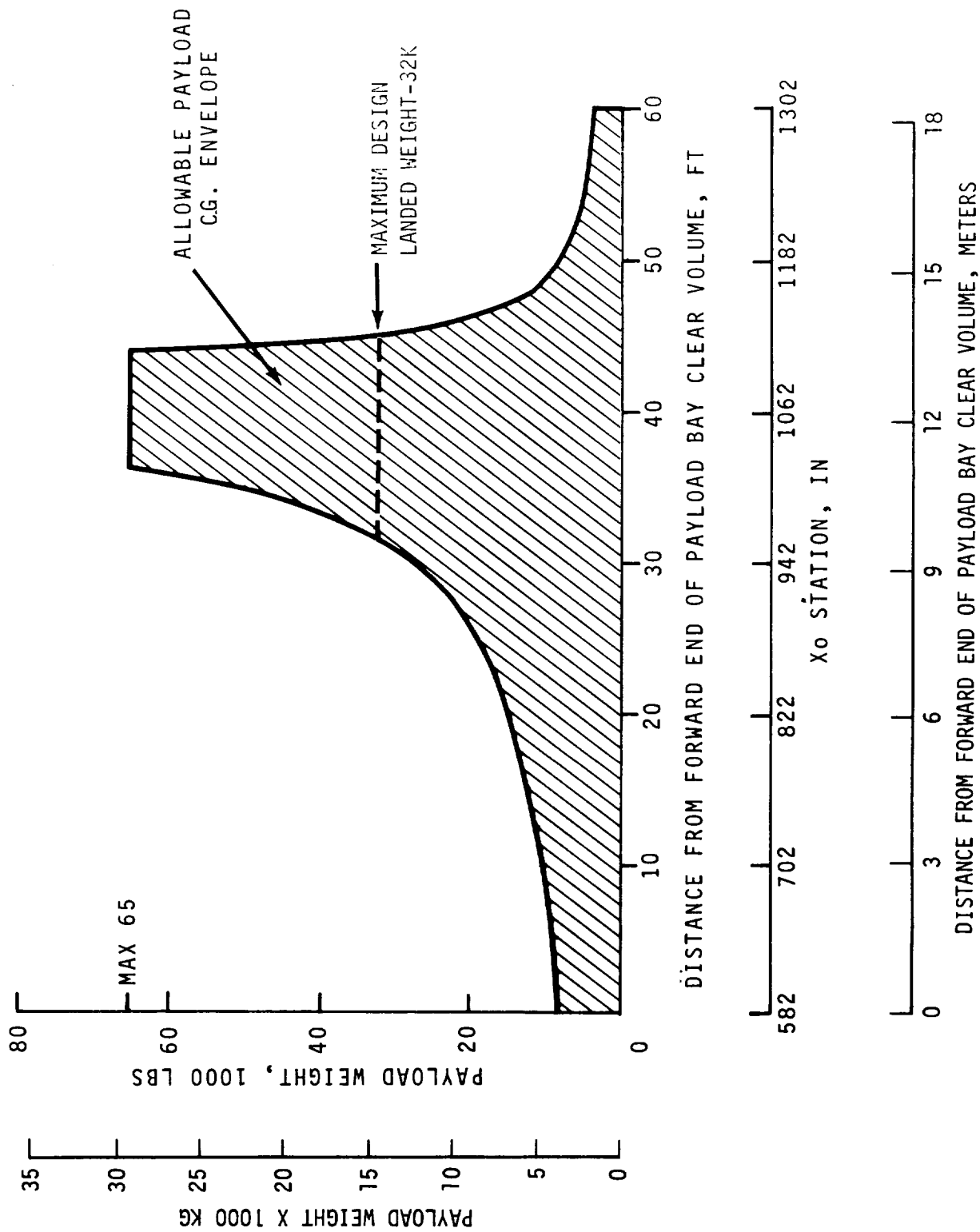


FIGURE 4-5 PAYLOAD LONGITUDINAL C.G. ENVELOPE

Figure 4-5 PAYLOAD LONGITUDINAL CG ENVELOPE (CONT.)

PAYLOAD WEIGHT, LBS x 10 ³	DISTANCE FROM P/L PAY (FT)		PAYLOAD WEIGHT, LBS x 10 ³	DISTANCE FROM P/L PAY (FT)	
	FWD C.G.	AFT C.G.		FWD C.G.	AFT C.G.
2.0	-	58.40	21.0	26.55	45.29
2.5	-	55.50	21.5	26.89	45.26
3.0	-	53.57	22.0	27.22	45.23
3.5	-	52.19	22.5	27.53	45.20
4.0	-	51.15	23.0	27.83	45.17
4.5	-	50.35	23.5	28.11	45.15
5.0	-	49.71	24.0	28.38	45.12
5.5	-	49.18	24.5	28.65	45.09
6.0	-	48.74	25.0	28.90	45.07
6.5	-	48.37	25.5	29.14	45.05
7.0	-	48.05	26.0	29.37	45.03
7.5	0.13	47.77	26.5	29.60	45.01
8.0	2.70	47.53	27.0	29.81	44.99
8.5	4.97	47.32	27.5	30.02	44.97
9.0	6.98	47.13	28.0	30.22	44.95
9.5	8.78	46.96	28.5	30.41	44.93
10.0	10.41	46.81	29.0	30.60	44.91
10.5	11.87	46.67	29.5	30.78	44.89
11.0	13.21	46.55	30.0	30.95	44.88
11.5	14.43	46.43	30.5	31.12	44.86
12.0	15.54	46.33	31.0	31.28	44.85
12.5	16.57	46.23	31.5	31.44	44.83
13.0	17.52	46.14	32.0	31.59	44.82
13.5	18.40	46.06	32.5	31.74	44.80
14.0	19.21	45.98	33.0	31.89	44.79
14.5	19.97	45.91	33.5	32.03	44.78
15.0	20.68	45.84	34.0	32.16	44.76
15.5	21.34	45.78	34.5	32.29	44.75
16.0	21.96	45.72	35.0	32.42	44.74
16.5	22.55	45.67	35.5	32.54	44.73
17.0	23.10	45.62	36.0	32.66	44.72
17.5	23.61	45.57	36.5	32.78	44.71
18.0	24.10	45.52	37.0	32.90	44.70
18.5	24.57	45.48	37.5	33.01	44.69
19.0	25.00	45.44	38.0	33.11	44.67
19.5	25.42	45.40	38.5	33.22	44.67
20.0	25.82	45.36	39.0	33.32	44.66
20.5	26.19	45.33	39.5	33.42	44.65

FIGURE B-5 PAYLOAD LONGITUDINAL CG ENVELOPE. (CONT.)

PAYLOAD HEIGHT, LBS x 10 ³	DISTANCE FROM P/L BAY (FT)		PAYLOAD WEIGHT, LBS x 10 ³	DISTANCE FROM P/L BAY (FT)	
	FWD C.G.	AFT C.G.		FWD C.G.	AFT C.G.
40.0	33.52	44.64	54.5	35.57	44.44
40.5	33.62	44.63	55.0	35.62	44.44
41.0	33.71	44.62	55.5	35.67	44.43
41.5	33.80	44.61	56.0	35.72	44.43
42.0	33.89	44.60	56.5	35.77	44.43
42.5	33.97	44.59	57.0	35.82	44.42
43.0	34.06	44.59	57.5	35.86	44.42
43.5	34.14	44.58	58.0	35.91	44.41
44.0	34.22	44.57	58.5	35.96	44.41
44.5	34.30	44.56	59.0	36.00	44.40
45.0	34.38	44.56	59.5	36.05	44.40
45.5	34.45	44.55	60.0	36.09	44.40
46.0	34.53	44.54	60.5	36.13	44.39
46.5	34.60	44.54	61.0	36.17	44.39
47.0	34.67	44.53	61.5	36.21	44.38
47.5	34.74	44.52	62.0	36.25	44.38
48.0	34.80	44.52	62.5	36.29	44.38
48.5	34.87	44.51	63.0	36.33	44.37
49.0	34.94	44.50	63.5	36.37	44.37
49.5	35.00	44.50	64.0	36.41	44.37
50.0	35.06	44.49	64.5	36.45	44.36
50.5	35.12	44.49	65.0	36.48	44.36
51.0	35.18	44.48			
51.5	35.24	44.48			
52.0	35.30	44.47			
52.5	35.35	44.46			
53.0	35.41	44.46			
53.5	35.46	44.45			
54.0	35.52	44.45			

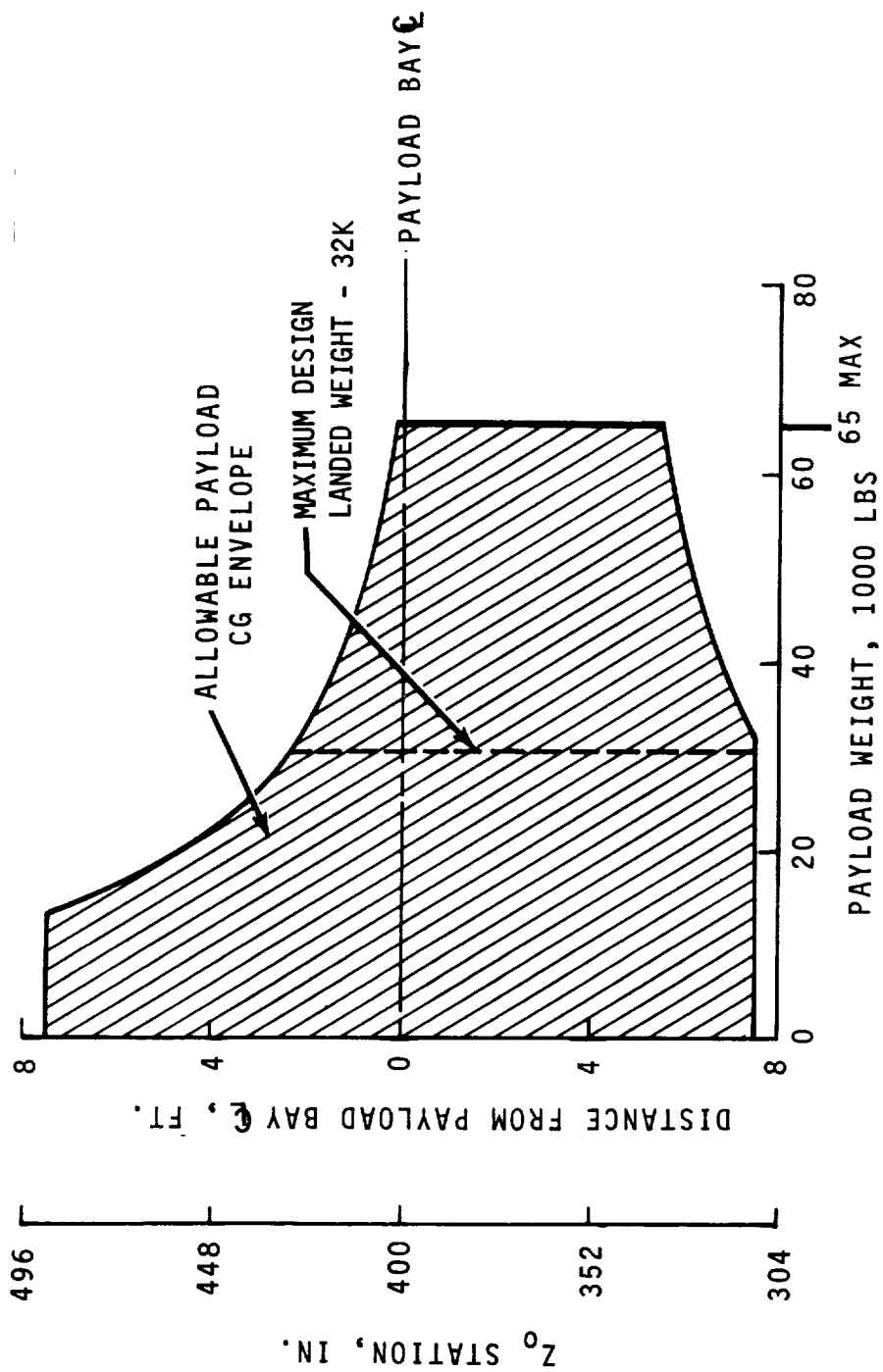
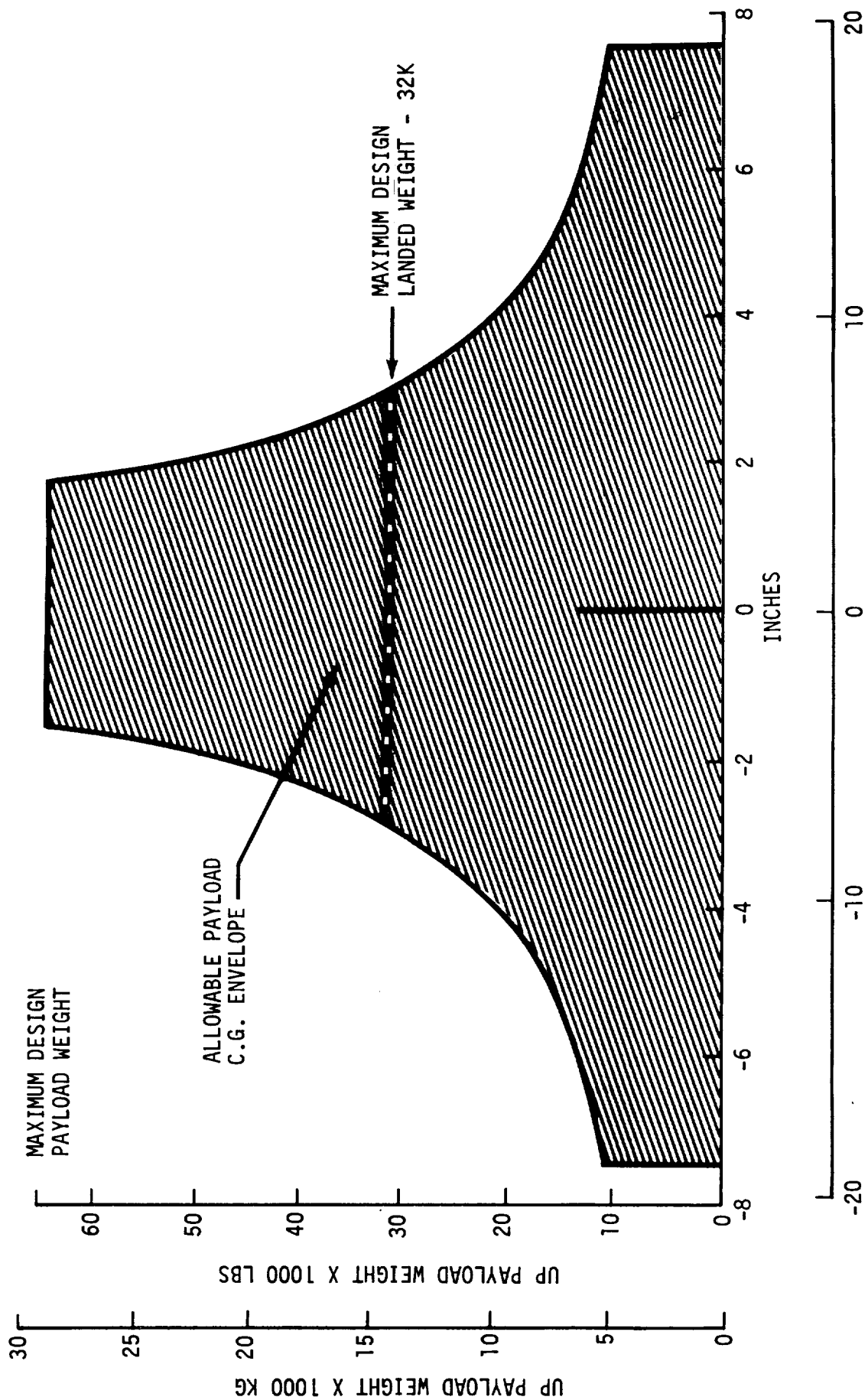


FIGURE 4-6.-PAYLOAD VERTICAL CG ENVELOPE

4-14



LATERAL DISTANCE FROM VEHICLE CENTERLINE IN CENTIMETERS

FIGURE 4-7 PAYLOAD LATERAL C.G. ENVELOPE

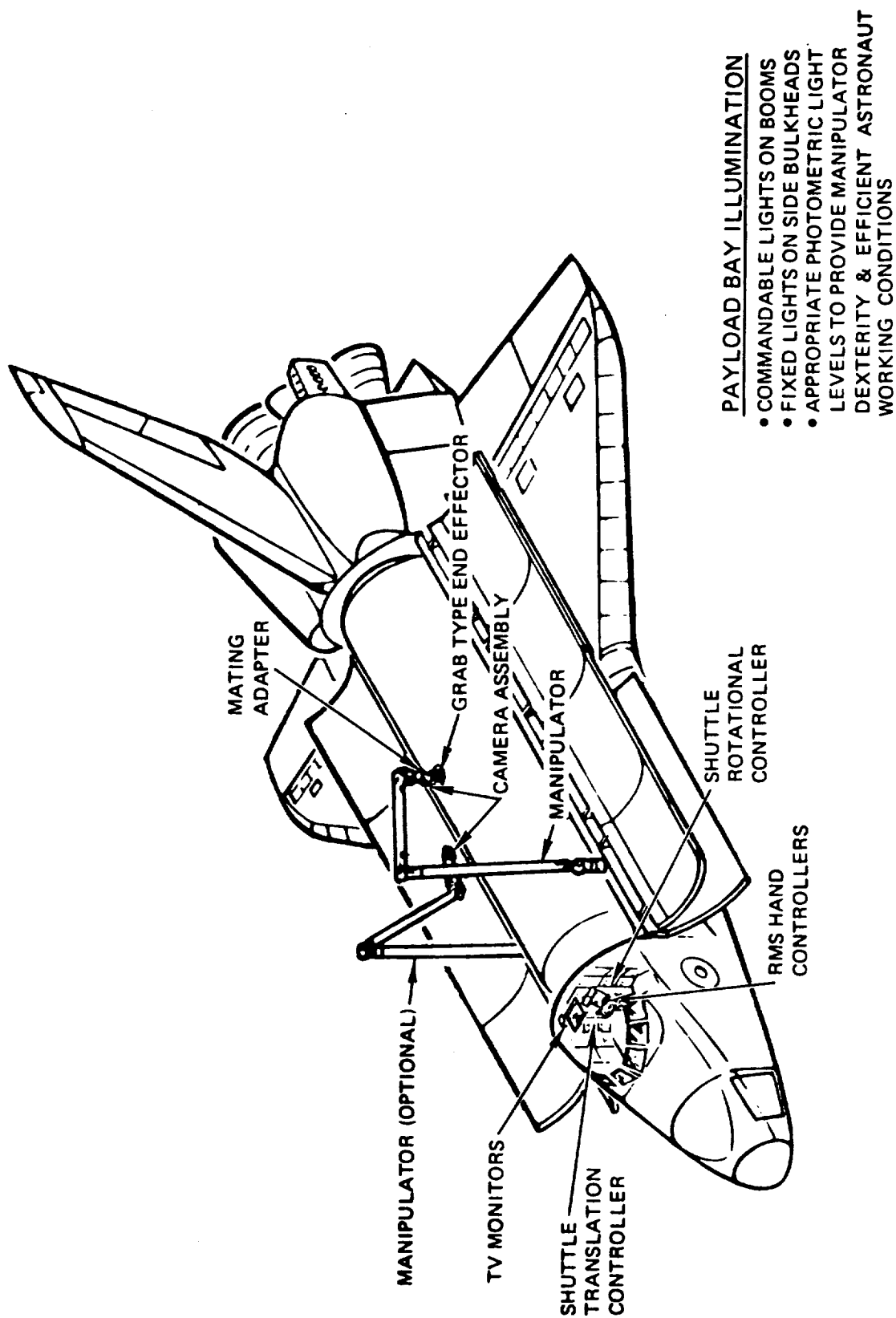


FIGURE 4-8. - DEPLOYMENT/RETRIEVAL SYSTEM
4-16

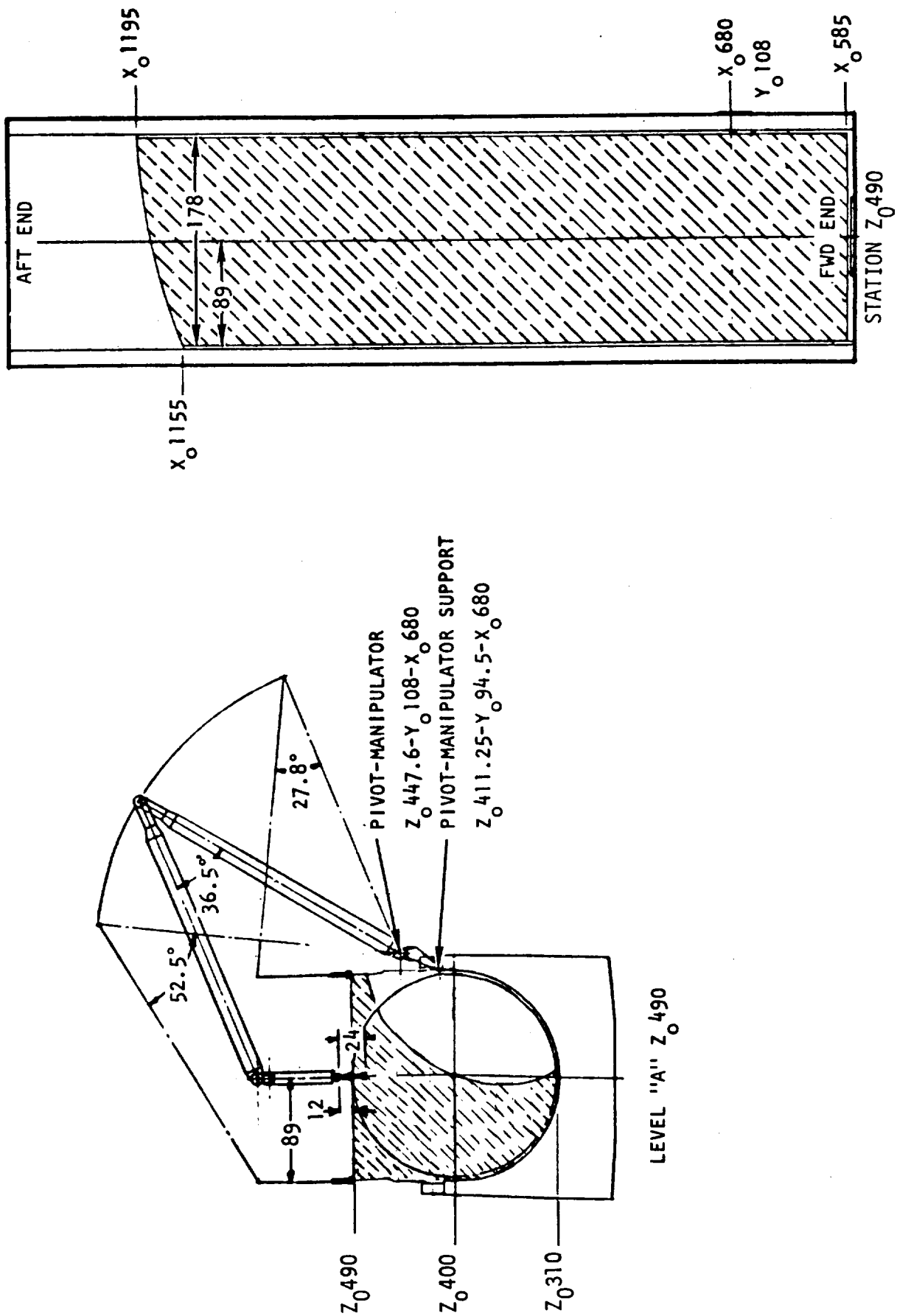


FIGURE 4.9 - REMOTE MANIPULATOR SYSTEM REACH CAPABILITY

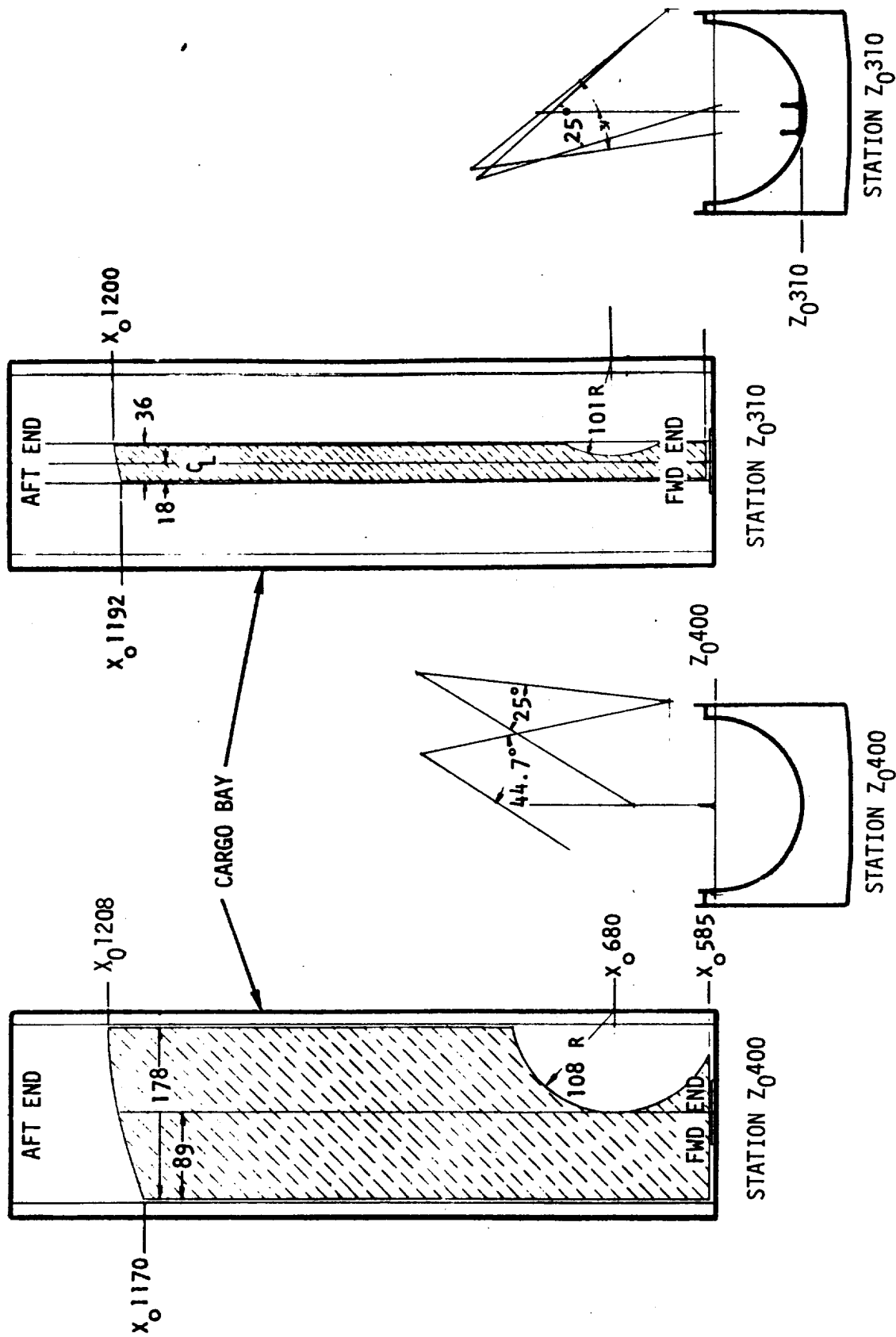


FIGURE 4.9. - REMOTE MANIPULATOR SYSTEM REACH CAPABILITY (CONT)

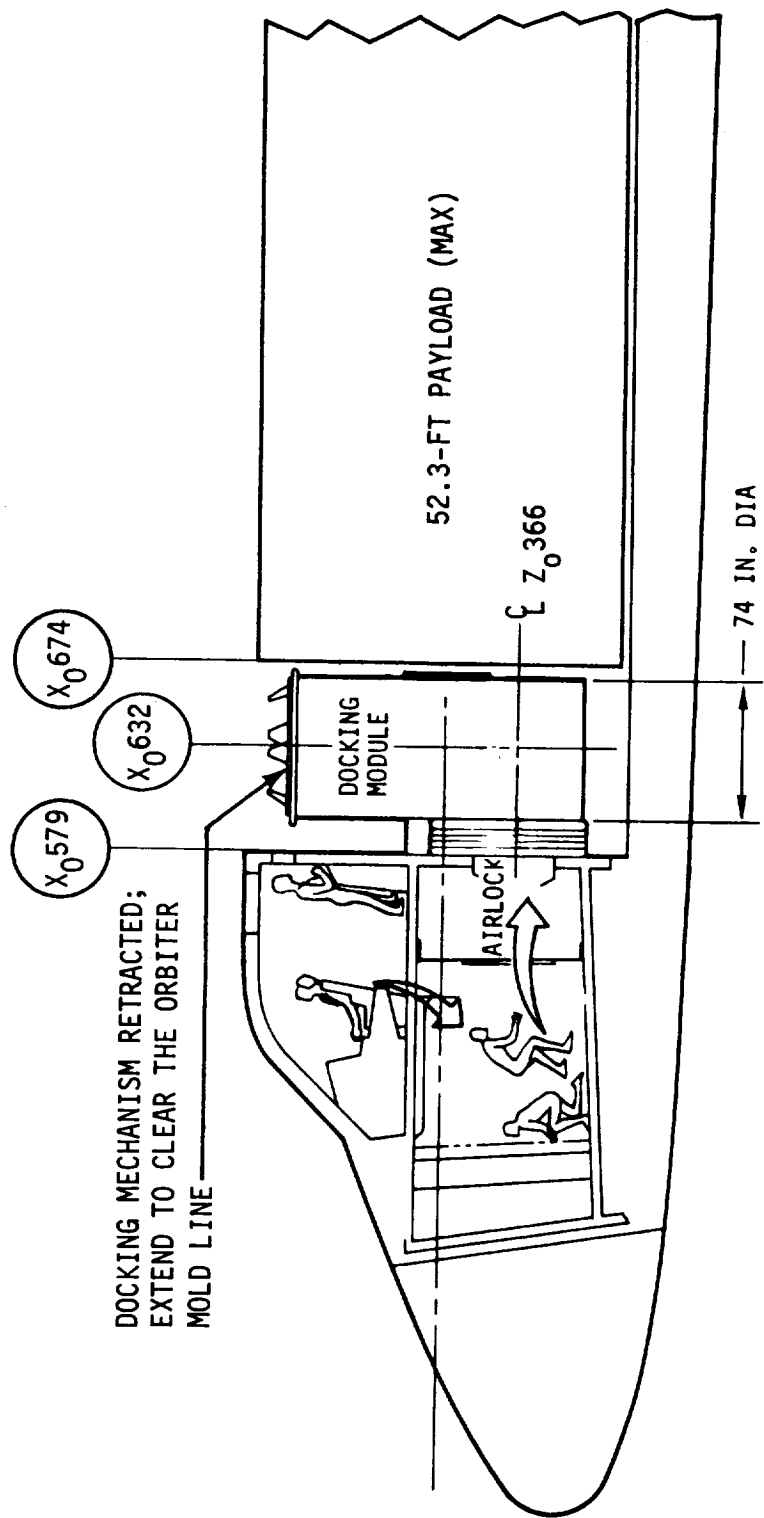


FIGURE 4-10. - ORBITER AIRLOCK/DOCKING MODULE INTERFACE

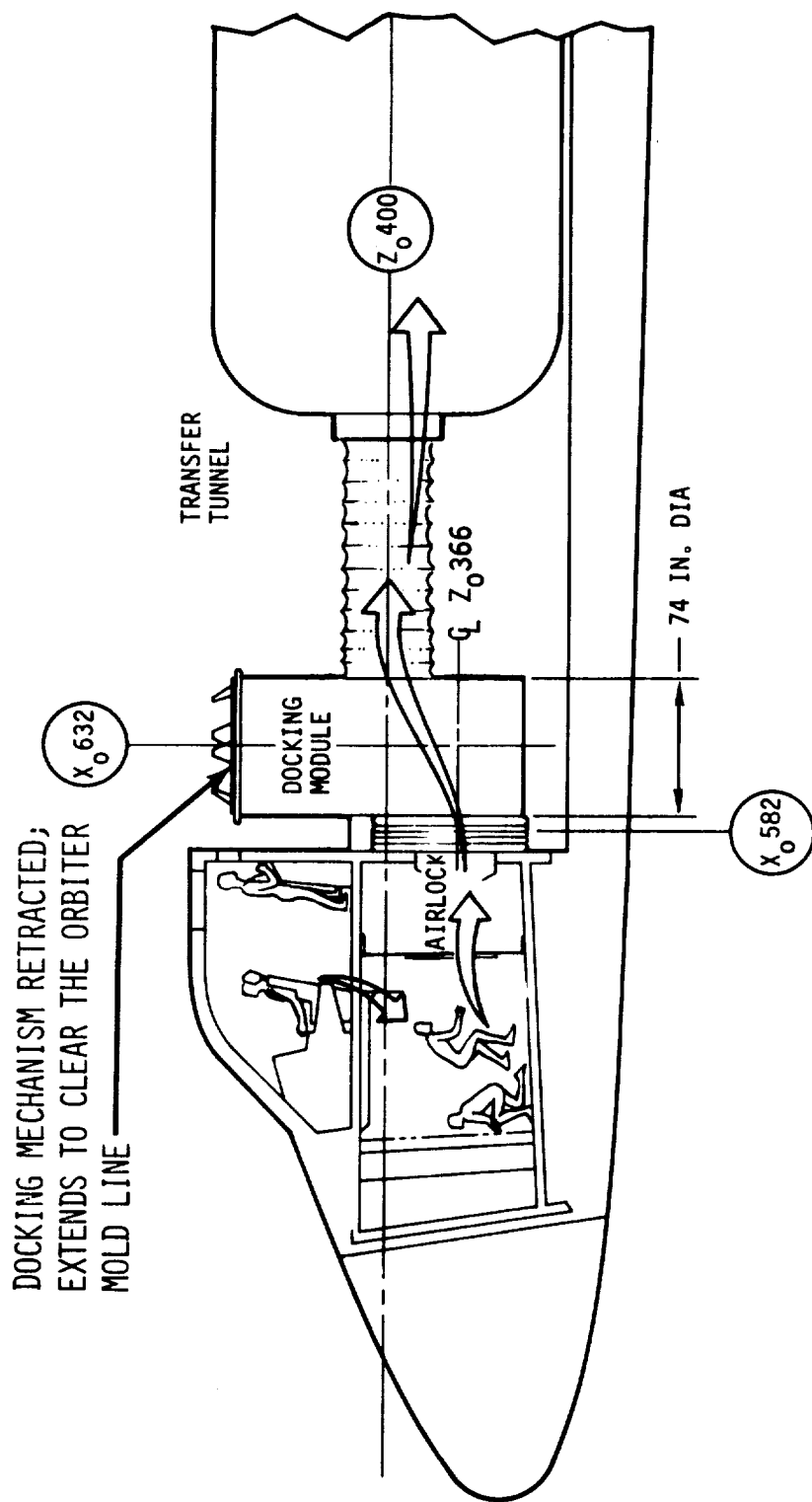


FIGURE 4-11. - ORBITER AIRLOCK/HABITAL PAYLOAD INTERFACE WITH DOCKING MODULE

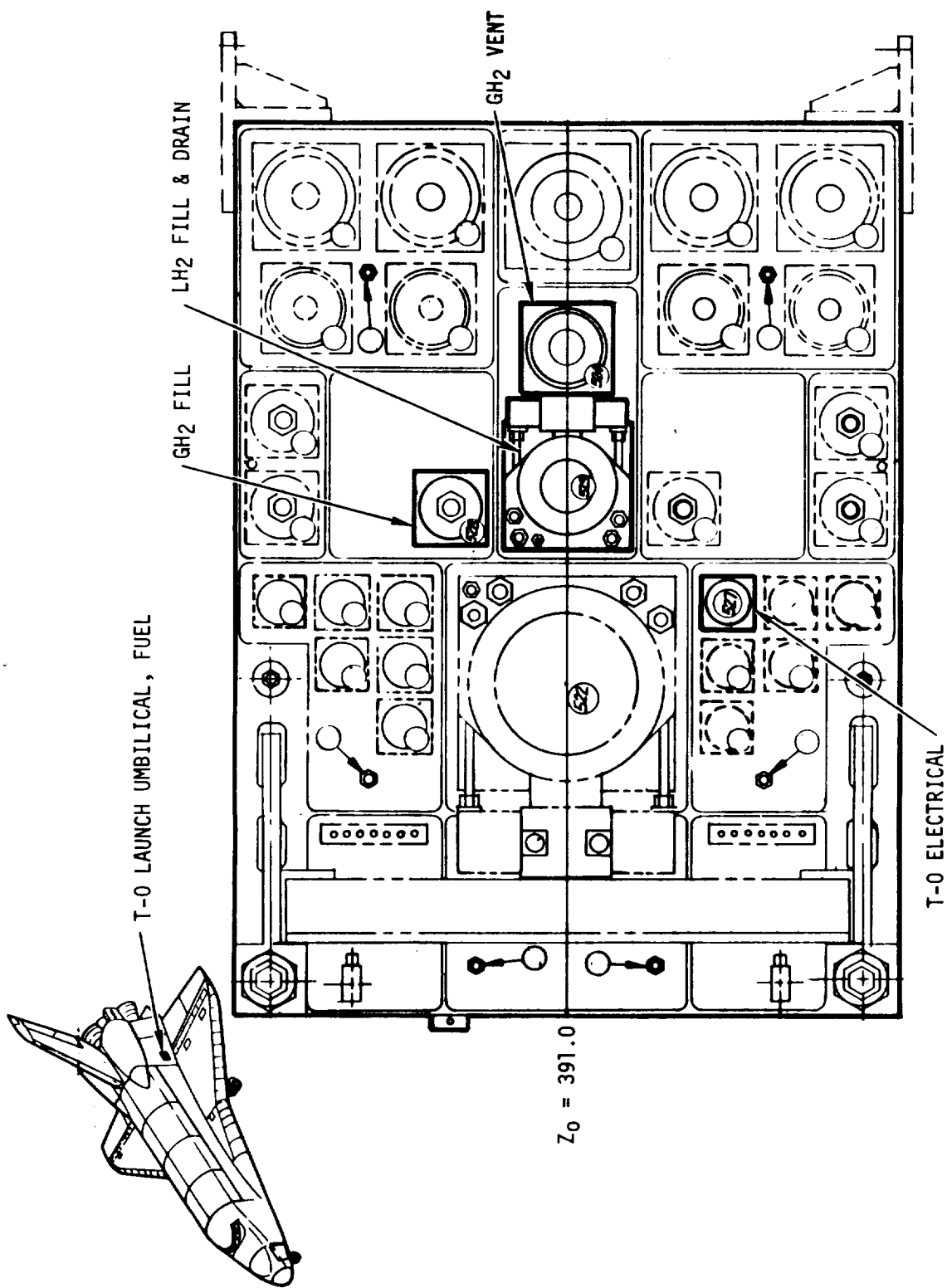


FIGURE 4-12. - LAUNCH UMBILICAL FUEL PANEL - PRELIMINARY

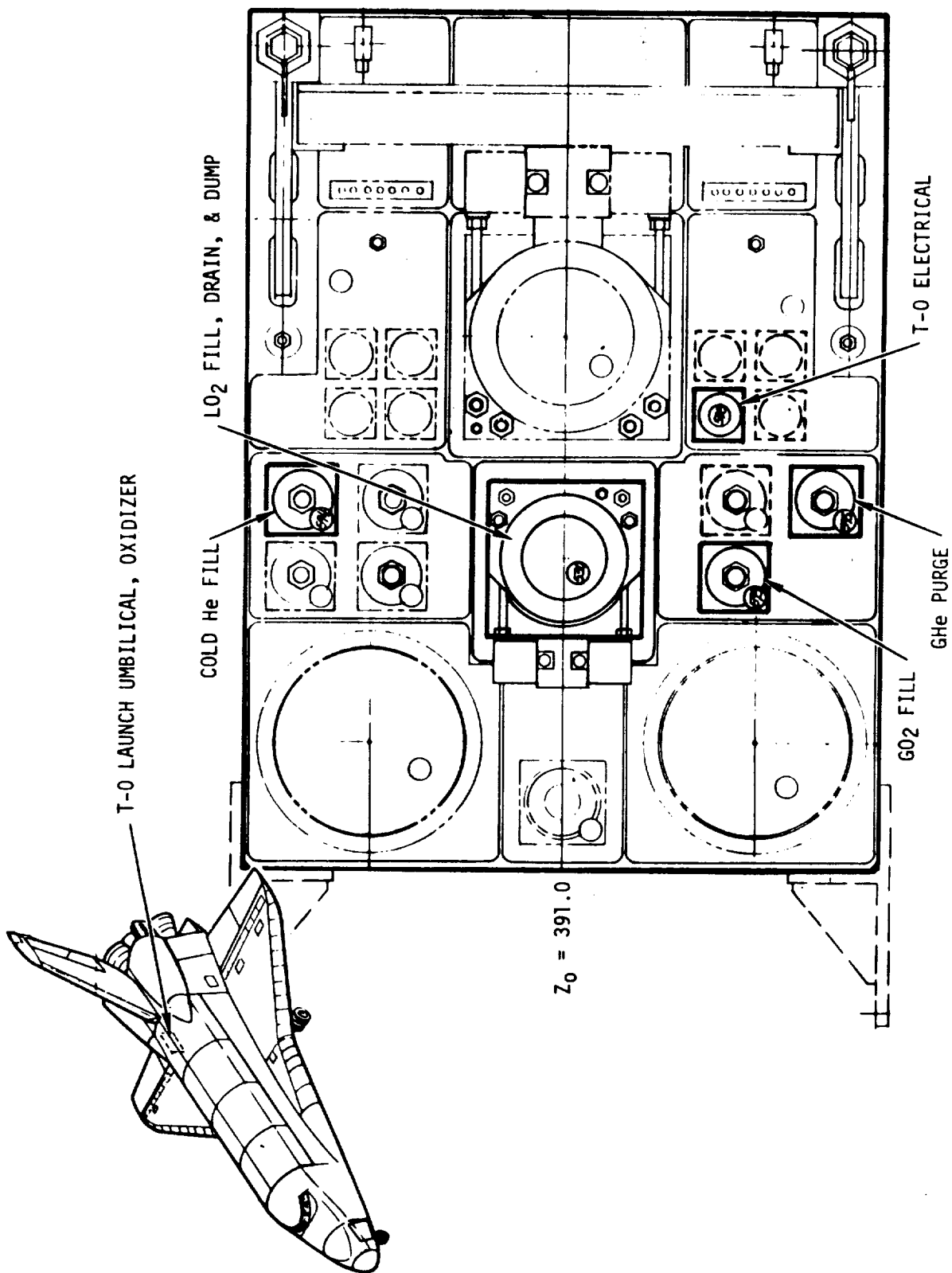


FIGURE 4-13. - LAUNCH UMBILICAL OXIDIZER PANEL - PRELIMINARY

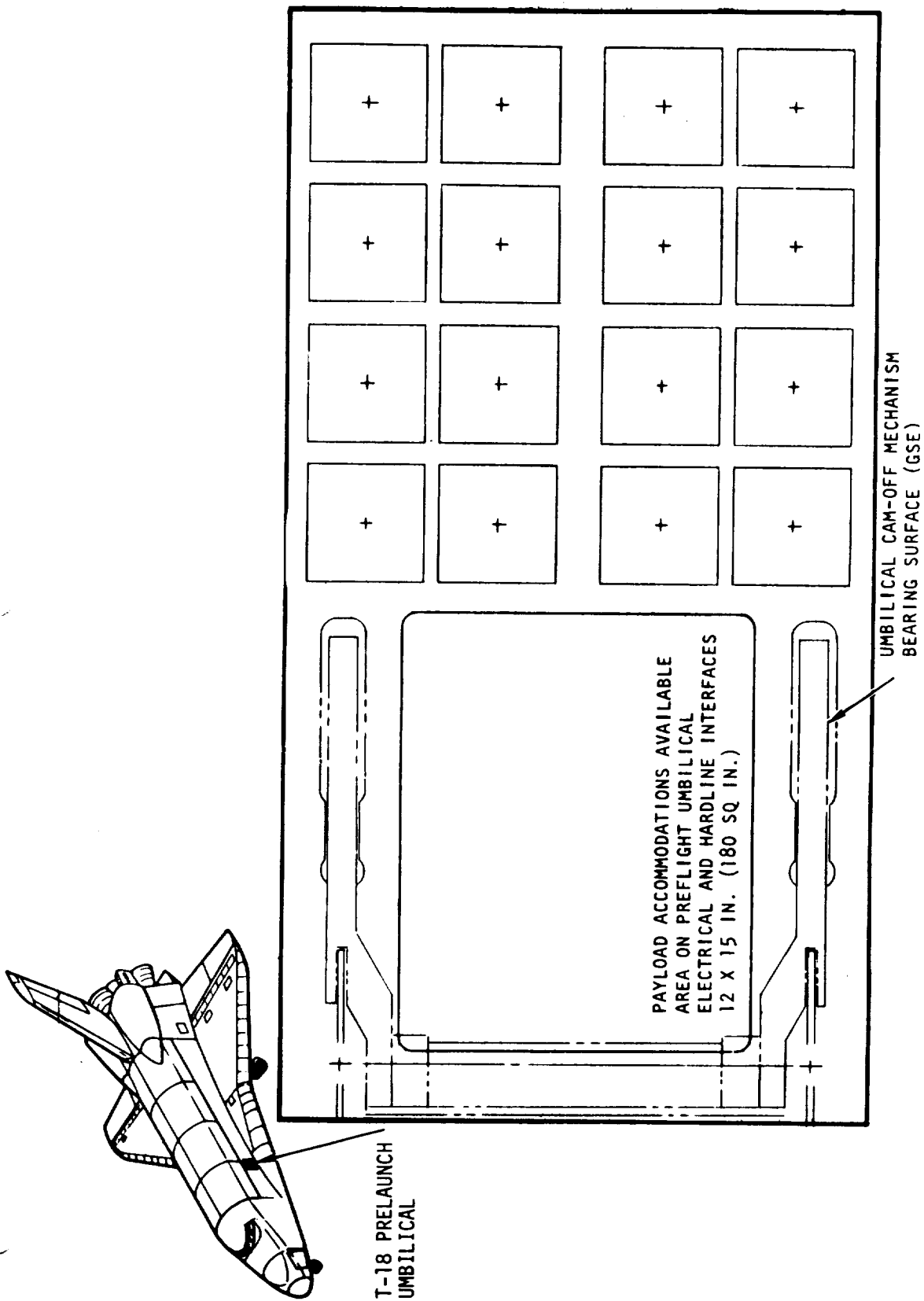


FIGURE 4-14. - PAYLOAD PRELAUNCH (T-18) UMBILICAL - PRELIMINARY

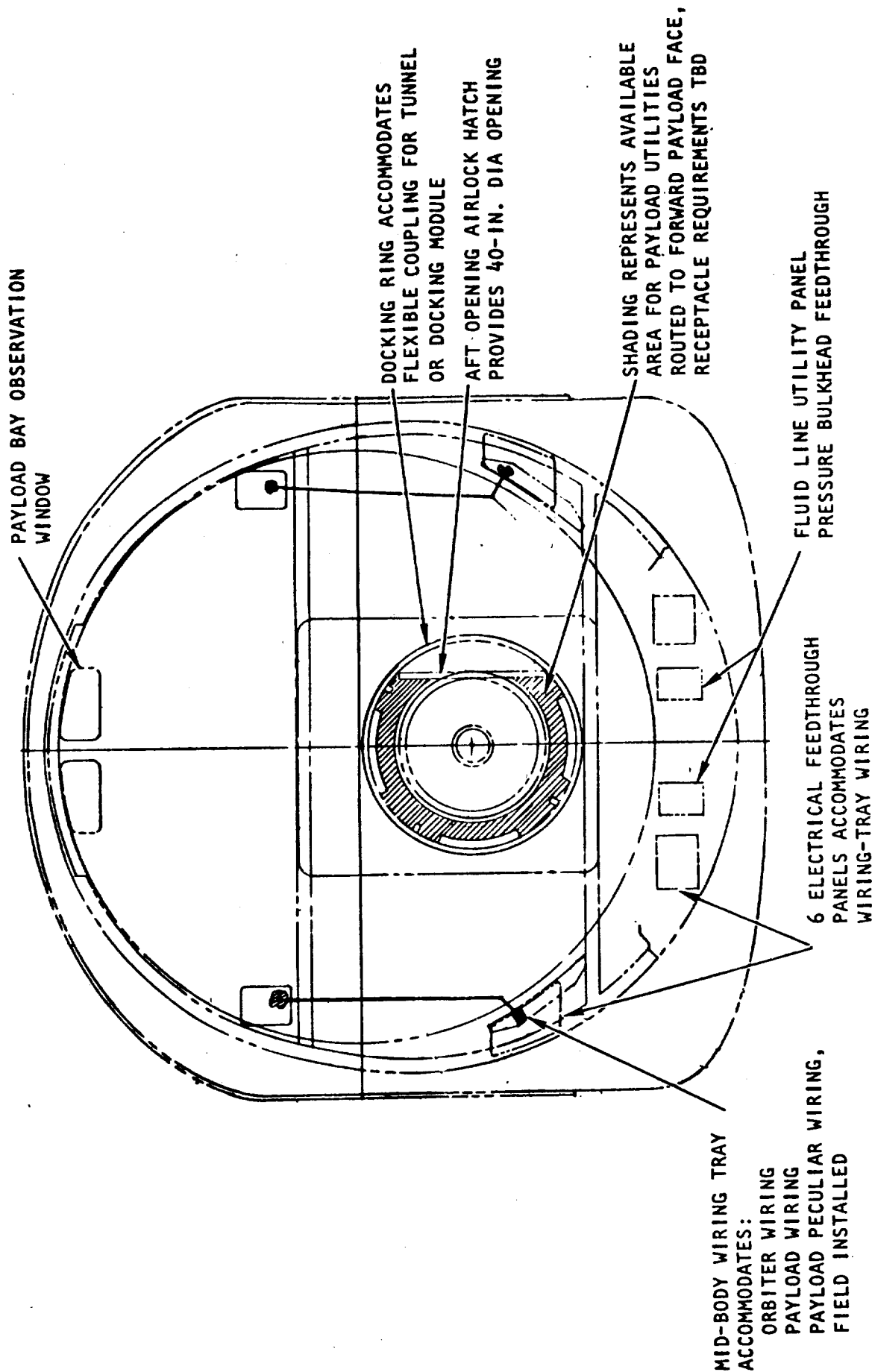


FIGURE 4-15. - STATION 576 BULKHEAD UTILITIES (LOOKING FORWARD) - PRELIMINARY

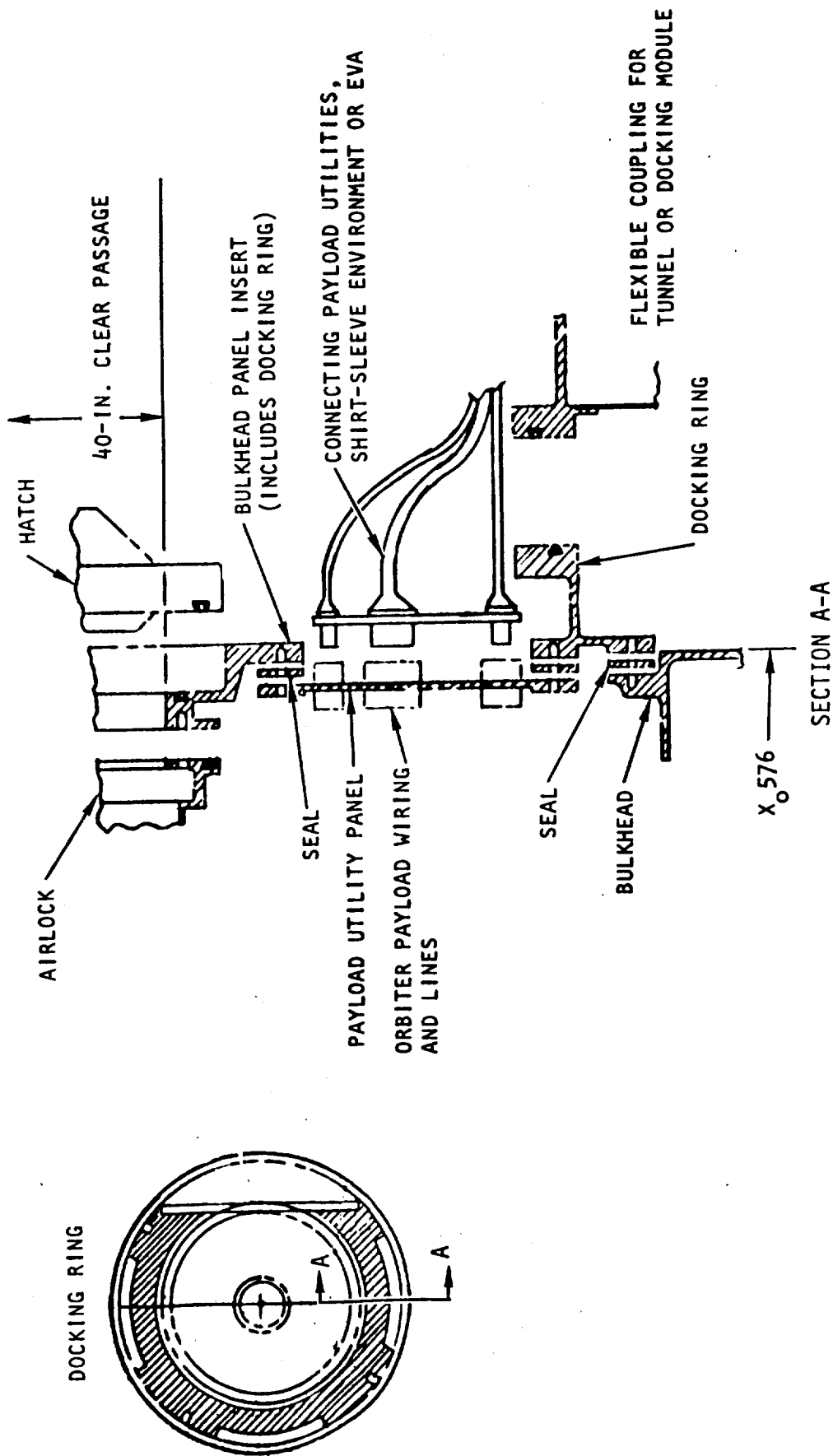


FIGURE 4-16. - PAYLOAD UTILITIES AT STATION 576 - PRELIMINARY

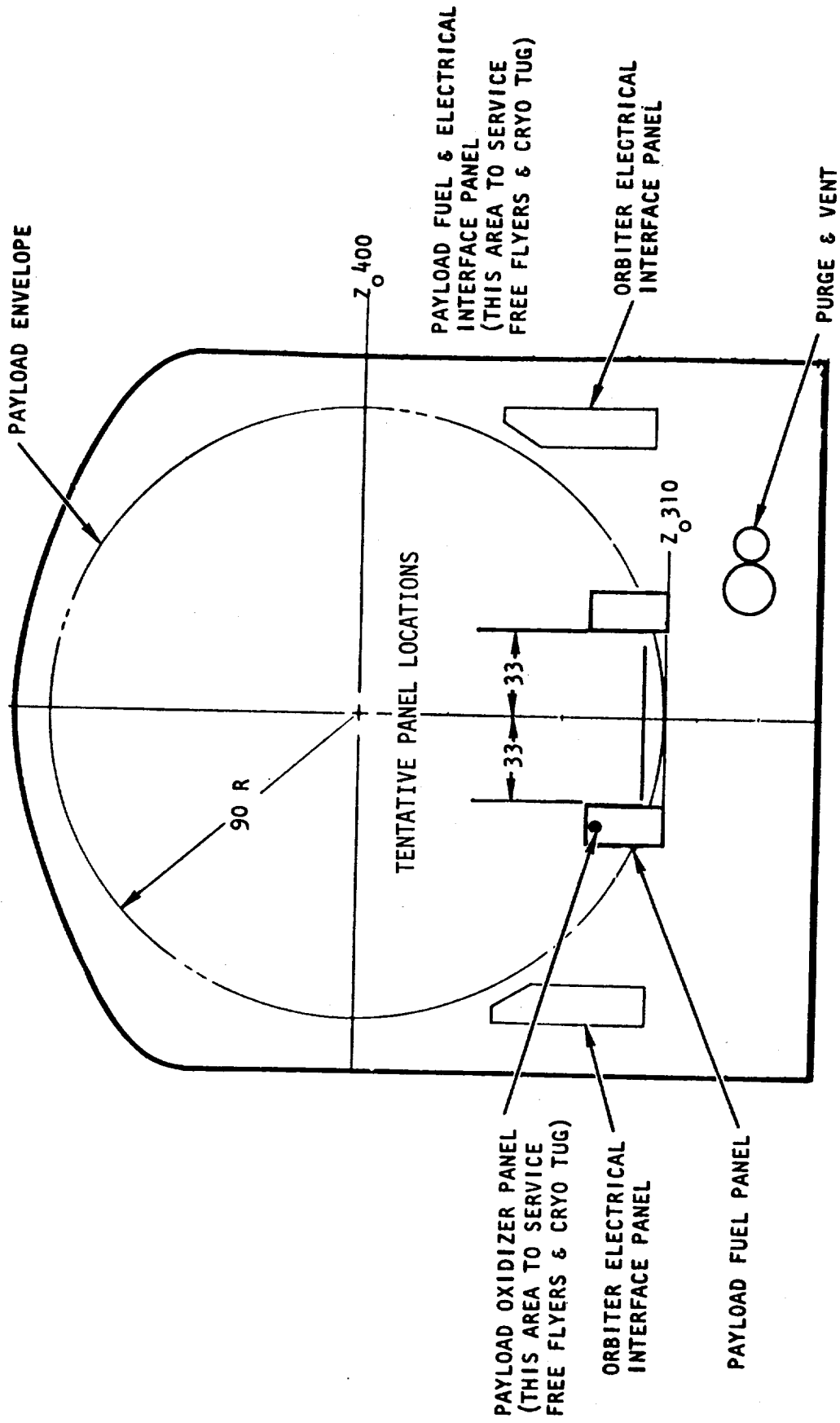


FIGURE 4-17. - STATION 1307 BULKHEAD UTILITIES (LOOKING AFT) - PRELIMINARY

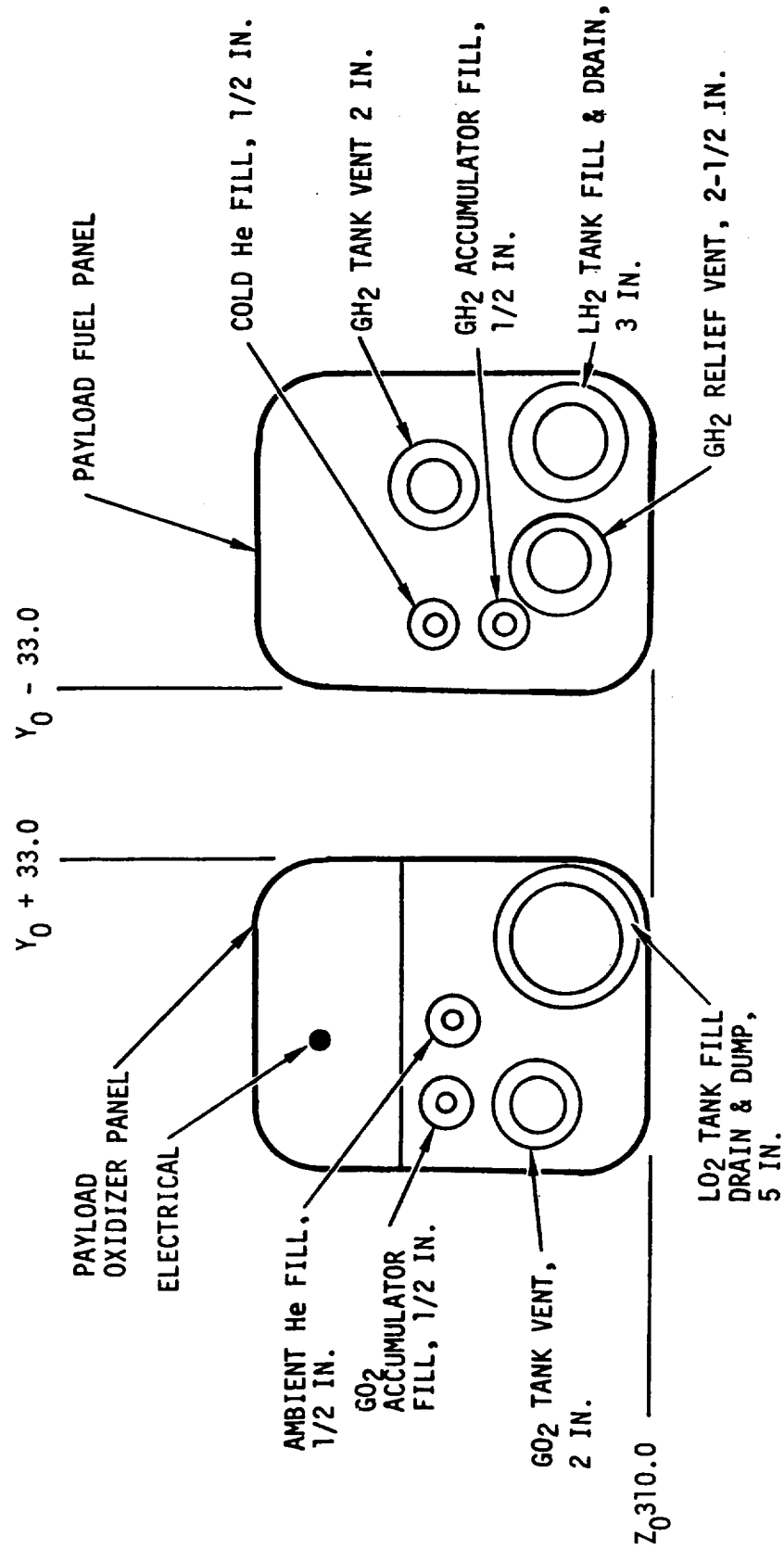


FIGURE 4-18. - AFT BULKHEAD PAYLOAD UTILITIES (LOOKING AFT) - PRELIMINARY

This page intentionally left blank.

5.0 AVIONICS

5.1 Guidance, Navigation and Control (GN&C). The GN&C subsystem provides: (1) automatic and manual control capability for all mission phases except docking, which is manual only; (2) guidance commands that drive control loops and provide steering displays for the crew; and (3) inertial navigation updated by RF navigation aids and during rendezvous by a rendezvous sensor.

An inertial measurement unit provides the navigation reference with star sensors for autonomous alignment. The Orbiter will provide through a standard interface to the payload the Orbiter state vector and attitude, Greenwich Mean Time, mission elapsed time, clock synchronization, and other data necessary to initialize the payload. The attitude information provided will not account for misalignment between the Orbiter reference system and the payload. The GN&C subsystem will have the capability of controlling Orbiter attitude by utilizing angle and/or rate data supplied by the payload. Range rate is derived from the rendezvous sensor range data. A star sensor may be used to track a target light to provide angle data for rendezvous navigation.

5.2 Data Processing and Software (DP&S). The DP&S provides the onboard digital computation to support the Orbiter subsystems and payloads. The hardware elements which comprise the data processing and software subsystem include the onboard computers, the mass memories, the adapting input-output elements, and the multiplexing/demultiplexing (MDM) units.

Payload checkout is provided at the mission specialist station via a cathode ray tube display, keyboard, computational capability (resident in the Orbiter DP&S) for payload monitoring, and a payload data interleaver. The Orbiter subsystems provide for software, data processing, command and control, data acquisition, and display capabilities required for payload functional end-to-end checkout and status monitoring through the Payload/Orbiter interfaces while the payload is installed in the payload bay. A main memory capacity of 10,000 32-bit words and 18 K equivalent computer adds per second are provided to perform these functions. The capability to overlay this 10,000 word segment of memory with programs from Orbiter mass storage is also provided. The orbiter will be capable of performing this checkout, monitor and command at any time after

PRECEDING PAGE BLANK NOT FILMED

liftoff. Payload caution and warning signals will be displayed to the flight crew and at the MSS.

Detailed acceptance testing of each payload by the user is performed by the user prior to installation in the Orbiter. Checkout of the payload for prelaunch operations after installation makes use of the ground checkout equipment and the Orbiter onboard checkout system for hardwired uplink commands to the payload. A hardwired downlink to the ground checkout equipment is also provided for checkout data, which is interleaved with Orbiter subsystem data.

The physical interfaces to the payload for inflight use are via the MDM's. A keyboard at the mission specialist station permits the mission specialist to communicate with the computer, and a cathode ray tube permits the display of payload checkout data to the mission specialist.

Checkout data are collected from the payload and sent to the payload data interleaver. These data can then be interleaved with Orbiter downlink telemetry, and either sent to the ground via the RF link or recorded.

Coaxial cables and wires are provided between the payload interface and the payload specialist station. These can be used for interfacing payload-provided displays, recorders, controls, etc., installed in the console at the payload specialist station, with payloads. Standardized interface connectors are provided on these wires. Time codes and synchronization frequencies can be made available from the Orbiter central timing unit, and transmitted to the payload.

5.3 Communications and Tracking.

5.3.1 General. The communications and tracking subsystem is that portion of the avionics system which provides for:

- a. Receiving, transmission, and distribution of voice.
- b. Transmission of operational telemetry.
- c. Receiving, processing, and transmission of payload telemetry.

d. Receiving, decoding, generation, and transmission of commands.

e. Transmission and distribution of television signals.

f. Tracking cooperative and passive targets

g. Transmission and reception of EVA data and voice

This subsystem provides the interface between the Orbiter and:

a. Tracking and Data Relay Satellite (TDRS) (Relay)

b. Space Tracking and Data Network (STDN) (Direct)

c. Attached Payloads

d. Released Payloads

e. EVA Crewmen

f. Air Traffic Control

g. Other interfacing subsystems

h. Other space vehicles

i. Orbiter vehicle landing site facilities

5.3.2 Functional Description. The functional description of the communication links provided are as follows:

5.3.2.1 Voice Communications. Voice communication is provided between crew stations and manned released payloads via RF links, and by interconnecting hardware and RF circuits to provide conference capability. The communications subsystem will provide voice conference capability. The communications subsystem will provide crewmen access to the following links for voice communication.

a. TDRS (relay) - Two independent duplex, 32 Kbps delta modulated digital voice channels when within the coverage zones of TDRS.

- (1) Downlink frequency band, 2200-2300 MHz
- (2) Uplink frequency band, 2025-2120 MHz

b. STDN (Direct) - Two independent duplex, 32 Kbps delta modulated digital voice channels when within coverage zones of STDN ground stations.

- (1) Downlink frequency band, 2200-2300 MHz
- (2) Uplink frequency band, 2025-2120 MHz

c. Attached Payloads - One duplex voice channel between the Orbiter crew members and personnel in a habitable payload.

d. Released Payloads - One duplex voice channel between the Orbiter crew members and personnel in a manned released payload.

- (1) Orbiter to Payload frequency band, 2025-2120 MHz
- (2) Payload to Orbiter frequency band, 2200-2300 MHz

e. EVA - Duplex voice communication with a conferencing capability for voice conversations between two EVA crewmen, other manned vehicles (Orbiter relay) and ground personnel (Orbiter relay).

5.3.2.2 Telemetry. The communications subsystem will transmit orbiter operational telemetry (with interleaved payload telemetry) and recorded telemetry as indicated for the following links.

a. Orbiter-to-TDES (Relay)

- S-Band Phase Modulation
- Frequency Band, 2200-2300 MHz
- 128 Kbps operational data (including up to 25 Kbps of interleaved payload data) time multiplexed with two 32 Kbps delta modulated digital voice channel and convolutionally coded 3:1 for a total channel rate of 576 Kbps.

b. Orbiter-to-STDN (Direct FM link)

- S-band, Phase modulation
- Frequency band, 2200-2300 MHz
- Time division multiplex, 192 Kbps serial data consisting of:
 - 128 Kbps operational data including up to 25 Kbps of payload data.
 - Two 32 Kbps delta modulated digital voice channels.

c. Orbiter to STDN (Direct FM link)

- S-band, Frequency Modulation
- Frequency band, 2200-2300 MHz
- Modulation consisting of one (at a time) of the following:
 - TV video
 - 1:1 operational PCM telemetry dump - 128 Kbps
 - 8:1 operational PCM telemetry dump - 1024 Kbps (max)
 - 256 Kbps attached payload telemetry or attached payload wide band data
 - Main engine data (real time)

d. Attached Payloads-to-Orbiter.

- Up to 25 Kbps of payload status data (hardline) to be interleaved with Orbiter operational telemetry.
- Up to 256 Kbps of payload data to be relayed to the ground via wideband FM transmitter.

e. Released Payloads-to-Orbiter

- S-band, Phase Modulation
- Frequency Band, 2200-2300 MHz
- TCM data as follows:
 - Manned payloads - up to 48 Kbps serial data consisting of one 32 Kbps digital voice channel and 16 Kbps telemetry
 - Unmanned payloads - up to 16 Kbps telemetry only

5.3.2.3 Commands. The communications subsystem will receive, decode, encode, and transmit commands as indicated for the following links.

a. IDRS-to-Orbiter (Relay). The command channel will consist of a 2.4 Kbps command information rate, of which 0.4 Kbps is allocated to vehicle and subsystem address overhead. This 2.4 Kbps command channel is encoded into a 6.4 Kbps bit stream prior to further processing and subsequent transmission over the RF link to the Orbiter. A 1.6 Kbps synchronization pattern is interleaved with the 6.4 Kbps command channel encoded rate providing a total command rate of 8 Kbps. The forward link characteristics are as follows:

- S-band phase shift keyed
- Frequency band, 2025-2120 MHz
- Time division multiplex, 216 Kbps serial data transmission rate consisting of the following data with 3:1 convolutional code:
 - Two 32 Kbps delta modulated digital voice channels
 - One 8 Kbps serial data command channel in encoded form based upon a 2.4 Kbps command information rate.

b. STDN-to-Orbiter (Direct). The command channel will consist of a 2.4 Kbps command information rate, of which 0.4 Kbps is allocated to vehicle and subsystem address overhead. This 2.4 Kbps rate is encoded (by the STDN command encoder) into a 6.4 Kbps bit stream prior to further processing and subsequent transmission over the RF link to the Orbiter. A 1.6 Kbps synchronization pattern is interleaved with the 6.4 Kbps encoded rate providing a total command rate of 8 Kbps. The forward link characteristics are as follows:

- S-band, Phase Modulated
- Frequency Band, 2025-2120 MHz
- Time division multiplex, 72 Kbps serial data consisting of:
 - Two 32 Kbps delta modulated digital voice channels
 - One 8 Kbps serial data command channel in encoded form based upon a 2.4 Kbps command information rate

c. Orbiter to Attached Payloads. The command channel (hardline) will consist of a 2.4 Kbps command information rate, of which 0.4 Kbps is allocated to vehicle and subsystem overhead. This 2.4 Kbps rate is encoded into a 6.4 Kbps bit stream prior to transmission to the payload. Commands may be generated either onboard the Orbiter or relayed from the ground. A 1.6 Kbps synchronization pattern is interleaved with the 6.4 Kbps encoded rate providing a total command rate of 8 Kbps.

d. Orbiter to Released Payloads. The command channel will consist of a 2.4 Kbps information rate, of which 0.4 Kbps is allocated to vehicle and subsystem address overhead. This 2.4 Kbps rate is encoded into a 6.4 Kbps bit stream prior to transmission to the payload. Commands will be generated onboard. The characteristics of this link are:

- S-band, Phase Modulation
- Frequency band, 2025-2120 MHz
- Time division multiplex (TDM) serial data as follows:
 - 40 Kbps for manned payloads consisting of one 32 Kbps delta modulated digital voice channel and one 8 Kbps in encoded form based upon a 2.4 Kbps command information rate.
 - 8 Kbps for unmanned payloads consisting of encoded command data and synchronization.

5.3.2.4 Doppler Tracking. The communications subsystem will provide for extraction of one-way Doppler onboard the Orbiter and for extraction of two-way Doppler at STDN (either direct or via TDRS).

5.3.2.5 Television and Wideband Experiment Data. The communications subsystem will provide the capability to transmit TV video or wideband experiment data to STDN ground stations via a link time-shared with wideband payload data. For analog data, the payload shall provide commutation and subcarrier oscillators compatible with the Orbiter wideband transmitter. For digital data, the payload shall perform the required encoding at a bit rate compatible with the capabilities of the Orbiter wideband transmitter.

5.3.2.6 Launch Readiness Checkout. Provisions will be made for both RF radiation and hardline (umbilical) interfaces between the Orbiter communications subsystem and launch facilities for prelaunch voice communications, telemetry, commands, TV, and wideband data.

5.3.2.7 Payload Tracking. The Orbiter will have an onboard capability of tracking a cooperative target during the last phasing, the coelliptic, and TPI maneuver. The capability will also be provided to track passive targets displaced up to 19 kilometers.

This page intentionally left blank.

6.0 ELECTRICAL POWER

Electrical power for payloads is provided by the Orbiter hydrogen/oxygen fuel cell power plants and will supply 1 kw average and 1.5 kw peak for payloads during all mission phases. During most of the orbital operations, the Orbiter has the capability to provide a maximum of 5 kw average and 8 kw peak power to the payload. Cryogenic storage volume and weight for 50 kwh of electrical energy for payloads is being provided. Any additional payload energy requirements will necessitate additional consumables, their tankage and additional plumbing which will be chargeable to payload weight. Such a system is being studied for possible availability in kit form which when installed would not interfere with the payload bay clear volume envelope. The electrical power characteristics at the payload interface will be as follows:

Power: 28 VDC nominal, two wire, structure ground
(Payload must not use structure for DC return)

Steady-state limits: 23-32.0 VDC intermittent duty
24-32.0 VDC continuous duty

Ripple voltage: 1 V peak-to-peak

This page intentionally left blank.

7.0 ORBITAL MANEUVERING AND REACTION CONTROL

7.1 Orbital Maneuvering Subsystem (OMS). The OMS provides the propulsive thrust to perform final injection into orbit, orbit circularization, orbit transfer, rendezvous, and de-orbit. The Orbiter integral OMS tankage is sized to provide propellant capacity for an on-orbit delta-V of 1,000 fps with a 65,000 pound payload on a mission from KSC into a 28.5 degree inclination. Provisions are made to allow additional tankage capacity to be incorporated to achieve an overall propellant capacity of 2.5 times that of the integral tankage for increased operational flexibility. The additional capacity is provided by three self-contained pressurant/propellant supply kits which will be located in the aft portion of the 15 feet diameter x 60 feet long payload bay clear volume and will be a payload weight chargeable item. The auxiliary tankage kit will be designed so that either one, two, or three sets of propellant and helium tanks can be installed as required by a particular mission. Figure 7-1 shows the installation of these kits in the payload bay.

7.2 Reaction Control Subsystem (RCS). The RCS employs bipropellant thrusters operating at a rated vacuum thrust of 900 pounds to provide attitude control and three-axis translational capability. Figure 7-2 illustrates the RCS plume profiles containing 95 percent of the exhaust products. Figure 7-3 illustrates the bipropellant flow exhaust cone for one of the RCS nozzles. Vernier thrusters operating at a rated vacuum thrust of 25 pounds have been incorporated to provide increased attitude hold capability. Figure 7-4 illustrates the vernier thruster plume profiles containing 95% of the exhaust products.

The Orbiter does not include a concept for RCS kits which could be included for additional capability. The propellant is stored in two separate tank systems, one forward and one aft with no fore to aft interconnect. Each tank system is sized for TBD pounds (presently estimated to be 3600 pounds although RCS tank sizing is under study). The aft tankage system consists of tanks located on either side of the Orbiter and has a side-to-side interconnect of the OMS/RCS propellant storage systems. This interconnect time shares the OMS crossconnects thereby increasing overall system flexibility. The RCS propellant available for payload operations is as described in Section 3.3. Vernier thruster propellant is stored in the forward tanks.

Specific impulse of the RCS thrusters and the Vernier thrusters is 289 and 232 seconds respectively.

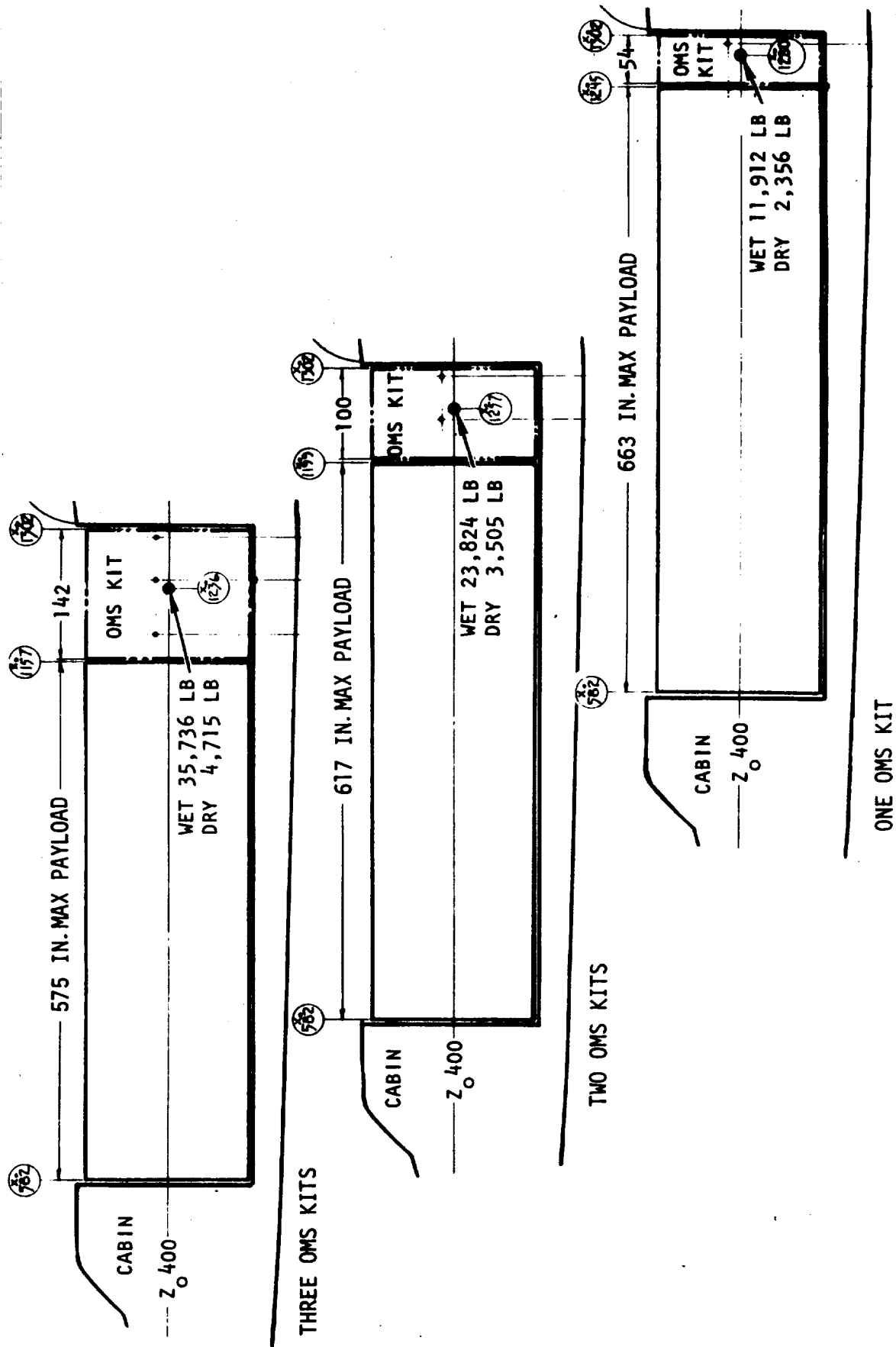


FIGURE 7-1. - OMS KIT INSTALLATION

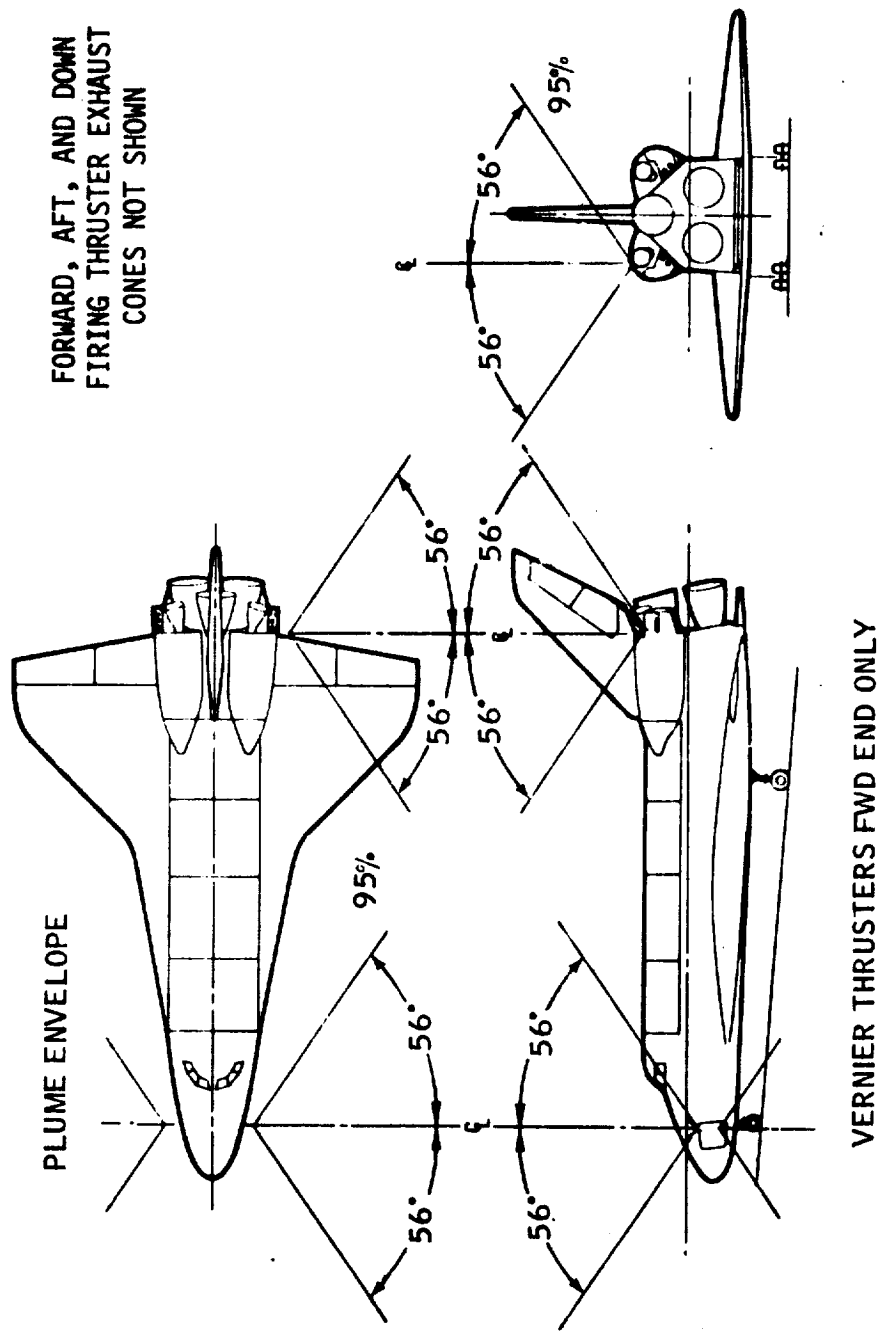


FIGURE 7-2. - 95% ENVELOPE OF RCS EXHAUST PRODUCTS

NASA-S-73-3207

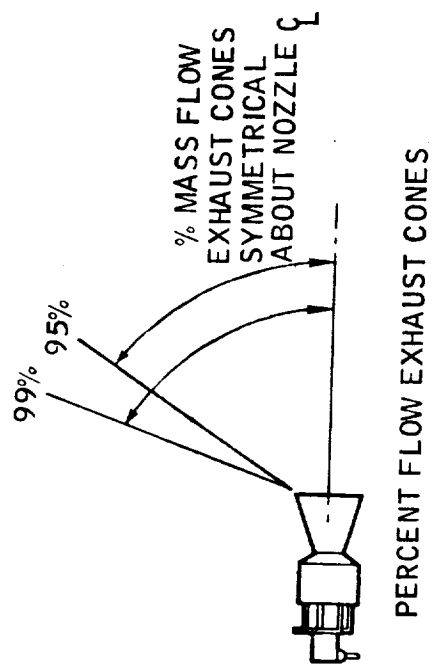


FIGURE 7-3. - RCS THRUSTER EXHAUST CONES

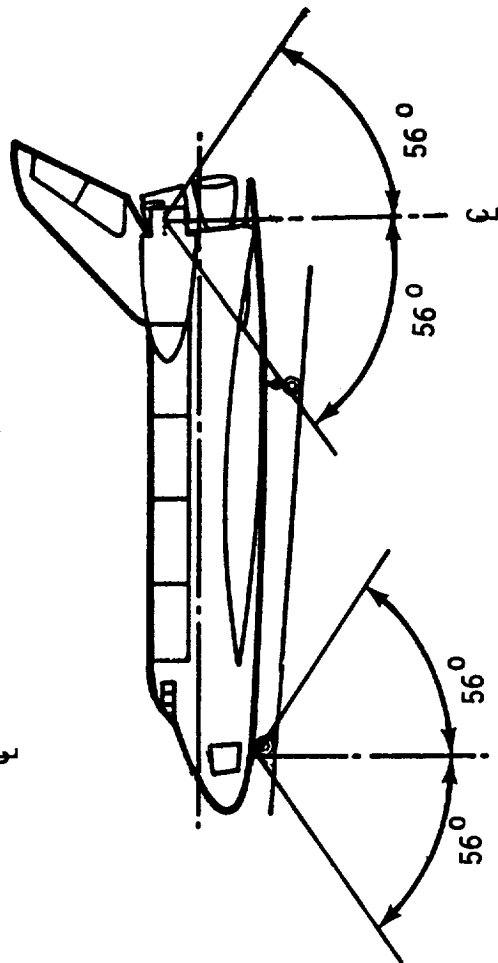
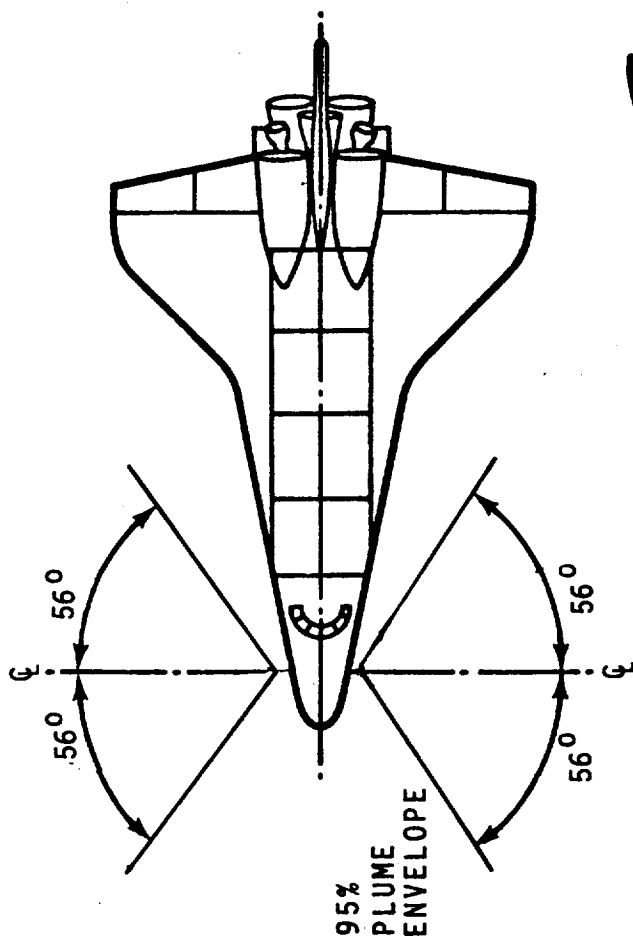


FIGURE 7-4. - RCS VERNIER LOCATION

7-6

8.0 ENVIRONMENTAL CONTROL AND LIFE SUPPORT

Environmental control and life support (ECLS) will include expendables storage capacity for a 42-manday mission (7 days duration) without modification to the Orbiter. However, the Orbiter is being designed so as not to preclude missions of long duration up to 30 days from being accomplished. A normal mission includes four men for 7 days (28 mandays) and the weight of expendables in excess of these 28 mandays must be charged to the payload. Up to a total of 7 personnel can be accommodated for shorter duration missions. All personnel in excess of four and provisioning for personnel in excess of four will be payload weight chargeable items.

8.1 Atmospheric Revitalization Subsystem (ARS). The ARS design will furnish a two-gas 14.7 psia shirt-sleeve environment by controlling CO₂, humidity, odor, pressure, oxygen/nitrogen atmosphere, and temperature for the cabin, cabin-located equipment, and habitable payloads.

The Orbiter will provide atmospheric revitalization of a habitable payload by circulation of 48 CFM of conditioned cabin air to support up to four personnel working in the payload. Assuming perfect mixing, the resulting atmosphere in a habitable payload is shown in Figure 8-1, 8-2, and 8-3. Figure 8-1 shows the relationship of the payload CO₂ partial pressure with the CO₂ production rate. The steady state CO₂ partial pressure in the habitable payload will be the partial pressure which results from the CO₂ entering with the conditioned air, which is expected to be between 1.0 and 2.5 mm Hg; plus that generated in the payload. Figure 8-2 shows the relationship between the payload atmosphere water vapor partial pressure and the total latent rate in the payload. The steady state water vapor partial pressure of the conditioned air in the payload will be the sum of that generated in the payload plus that contained in the air entering the payload. The dewpoint temperature of the air entering the payload nominally will range between 45°F and 50°F with a maximum of 55°F. Figure 8-3 shows the quantity of heat that the entering conditioned air can remove from the payload atmosphere and the resulting temperature rise of the air. The temperature of the air entering the payload will range between 45°F and 65°F and will normally be less than 55°F. It should be noted that the temperatures of the payload atmosphere and the return air to the Orbiter cabin are the same.

8.2 Food, Water, and Waste Management Subsystem. The food management section consists of a galley area for food preparation, food and equipment storage, hot and cold water dispensers, and waste storage.

The water management section stores, distributes, and disposes of excess potable water and collects and stores waste water. Potable water is stored in three tanks, each having a capacity of 100 pounds. When the potable storage tanks are fully charged, the system pressure will rise to 20 psi above cabin pressure. With continued fuel cell product water flow, the tanks will become full and controlled disposal is accomplished by the water sublimator or dumped overboard through heated nozzles depending on the operational constraints. For emergency, the water will be dumped overboard through two heated nozzles. Waste water condensate from the humidity control heat exchanger is stored in three tanks, each of 165-pound capacity and normal operating pressure of 14.7 psia.

The waste management section accumulates solid waste and collects, transfers, and stores liquid wastes. Urine and urinal rinse are collected, separated from air, and stored for return to earth.

The waste management system shall be usable by male or female crew members. Personnel hygienic facilities including waste and trash storage shall be provided.

8.3 Active Thermal Control Subsystem (ATCS). The ATCS provides heat transport, equipment thermal control, and heat rejection for all mission phases, including ground operations.

The ATCS provides equipment for controlled circulation of liquid Freon 21 between various thermal sources and sinks located outside the habitable Orbiter crew compartment. The ATCS also provides active thermal control of the payload. The payload thermal control loop will interface with the Orbiter ATCS through a heat exchanger located in the Orbiter and dedicated to support the payload in the payload bay. The temperature of the coolant that is provided to the payload is determined by using the information shown in Figure 8-4. The payload will be responsible for providing the payload heat transport thermal control hardware to interface with the Orbiter ATCS interface heat exchanger. The average active heat rejection capacity dedicated to payloads will be as follows:

Nominal, 3400 Btu/hour

Peak, 5200 Btu/hour

During orbital operations, when Orbiter electrical power requirements do not exceed 8 kw, the heat rejection capacity for payload usage may be increased to as much as:

Nominal, 11,250 Btu/hr

Peak, 21,500 Btu/hr

Space radiators are the primary heat sink during orbital operations. The radiators are stowed beneath the payload bay doors during launch and re-entry. During most orbital operations, the radiators are normally deployed to allow an unobstructed 180 degrees lateral field of view for the payload at the upper surface of the payload bay door frame. No Orbiter attitude restrictions or water boiling are currently required by the radiators in order to reject maximum anticipated heat loads.

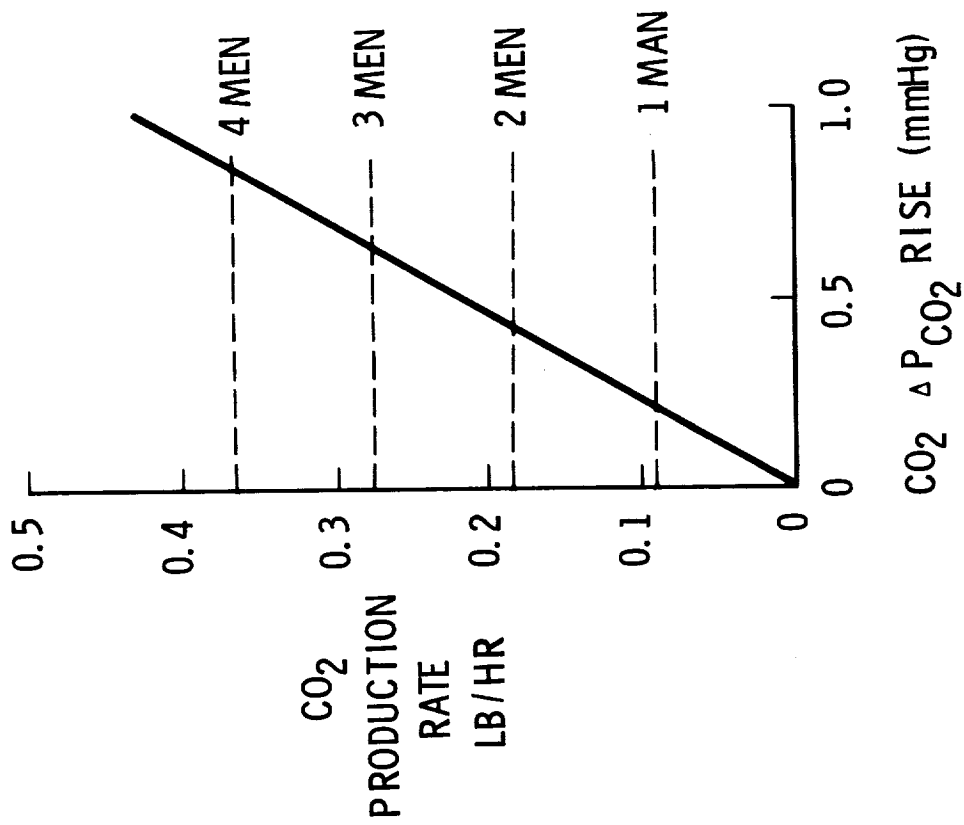


FIGURE 8-1.- INCREASE IN HABITABLE PAYLOAD CO₂ PARTIAL PRESSURE

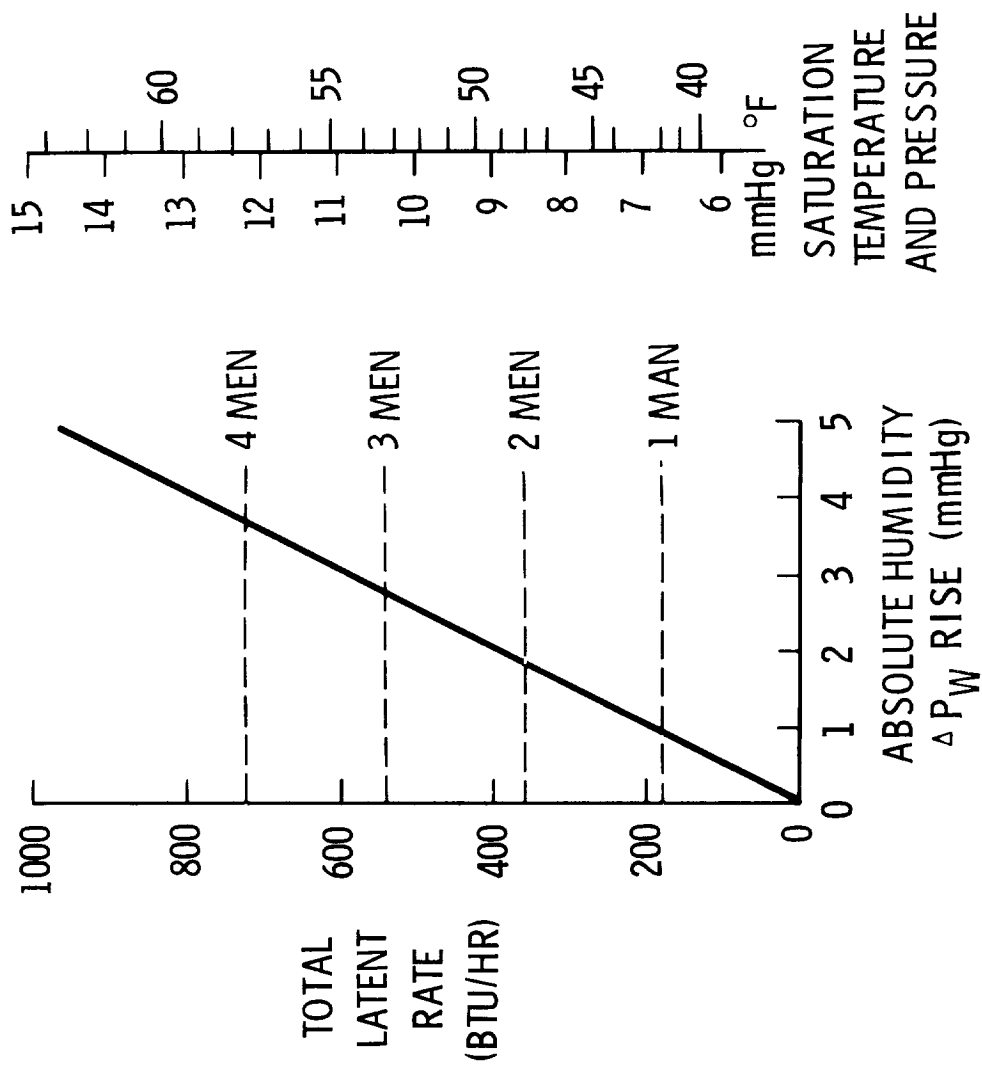


FIGURE 8-2.- INCREASE IN HABITABLE PAYLOAD ABSOLUTE HUMIDITY

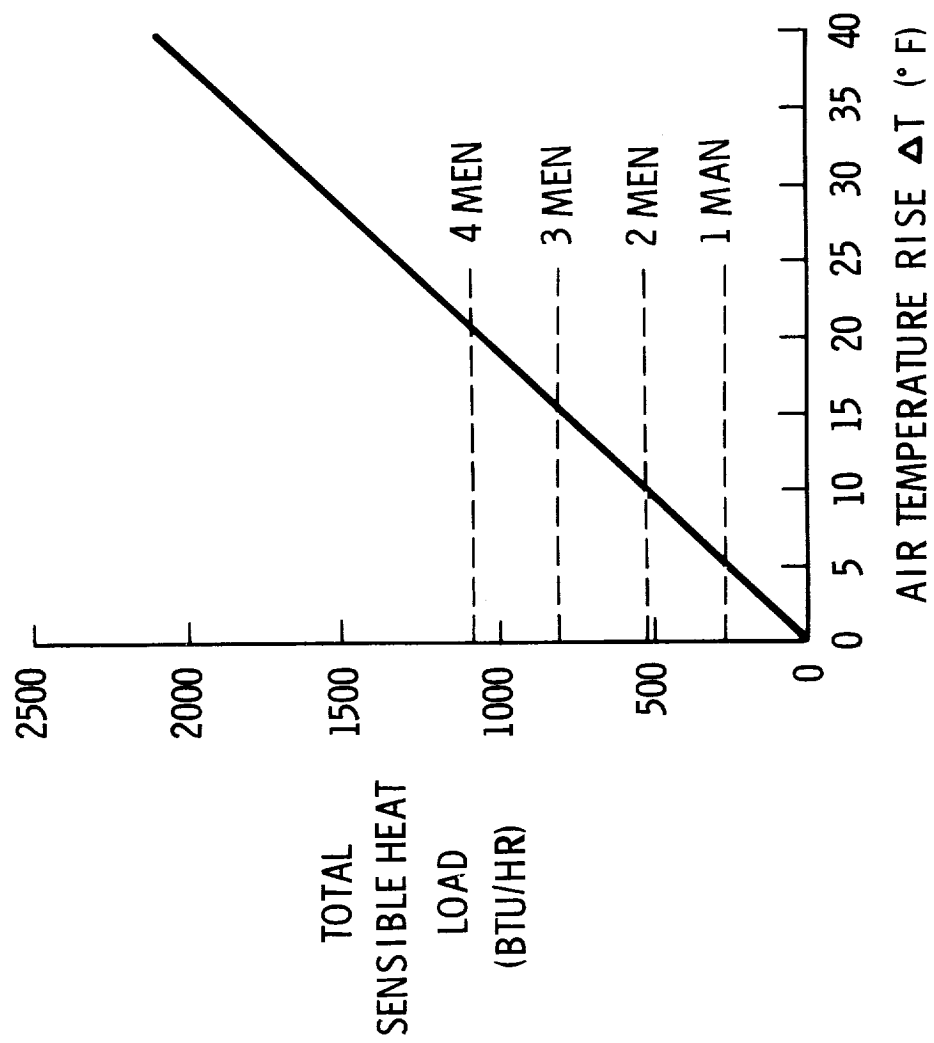


FIGURE 8-3. - INCREASE IN HABITABLE PAYLOAD AIR TEMPERATURE

**Figure 8-4 Habitable Payload Coolant Inlet Temperature
To be supplied later.**

This page intentionally left blank.

9.0 CREW PROVISIONS

9.1 Crew Compartment. The Orbiter crew compartment consists of a two-level cabin, as shown in Figure 9-1. The upper level (flight section) is dedicated to flight and payload operations. The commander and pilot flight control stations and on-orbit stations for docking and payload handling, the mission specialist station, and the payload specialist station are located on the upper level as shown in Figures 9-2 and 9-3. The arrangement of the payload handling station, mission specialist station, and payload specialist station is such that all three can be manned simultaneously for limited time periods when required. The off-duty habitability area and additional crew provisions are located on the lower level (midsection).

9.2 Mission Specialist Station. The mission specialist station provides the necessary means for managing Orbiter/payload interfaces and supporting operation of active payloads.

This station provides the capability to command, control, monitor, and communicate with attached or detached payloads. Voice communication is provided with the ground and with other crewman stations. Payload data recorders can be controlled to play back data for transmission. The capability to manage payload specialist station voice, TV, and telemetry data transmission will be provided. The station configuration will include provisions for the mission specialist to man the station for short or extended time periods and whenever the payload specialist station is manned.

9.3 Payload Specialist Station. The payload specialist station has standard racks for the installation of payload-supplied displays and controls. A minimum of 20 square feet of panel space has been reserved for payload unique displays and controls. Figure 9-4 shows the general arrangement of the available panel space. A minimum of 30% of the panel area reserved has a clearance in depth of at least 20 inches. Standard electrical interfaces for payload command, control, monitor, and checkout will be available. In addition, there will be provisions for closed circuit TV, payload data display and recording, and communications with attached or detached payloads and ground. Voice communication will be provided with the ground and other crew stations. Payload visibility is available to the

payload specialist by access to the payload handling station windows and television monitors. Electrical power will be provided to this station through standard connectors. Payload supplied equipment requiring heat removal must be provided with forced air cooling capability. The configuration will include provisions for the station to be manned for short duration or extended periods at appropriate times.

9.4 Payload Handling Station. The payload handling station is used to control payload deployment, payload retrieval, docking, and other related activities. Direct visibility for this on-orbit station is provided by overhead and aft-facing windows. The limits of the line of direct visibility from the payload handling station of the payload bay, without a payload and without a docking module are shown in Figure 9-5. This station has, in addition to permitting direct visibility, a closed circuit TV system. TV cameras, located near the terminator of each manipulator arm, provide visibility so that final closure and attachment may be accurately controlled. Other TV cameras are mounted in the payload bay and provide remote viewing of the payload attachment and release and stowage operations as well as general viewing of the entire area. Another TV camera is used within the docking module and mounted on the centerline of the docking axis at the payload handling station window to aid manipulator-controlled docking operations. Two television monitors are provided in the right-hand panel of the payload handling station, near the payload specialist station.

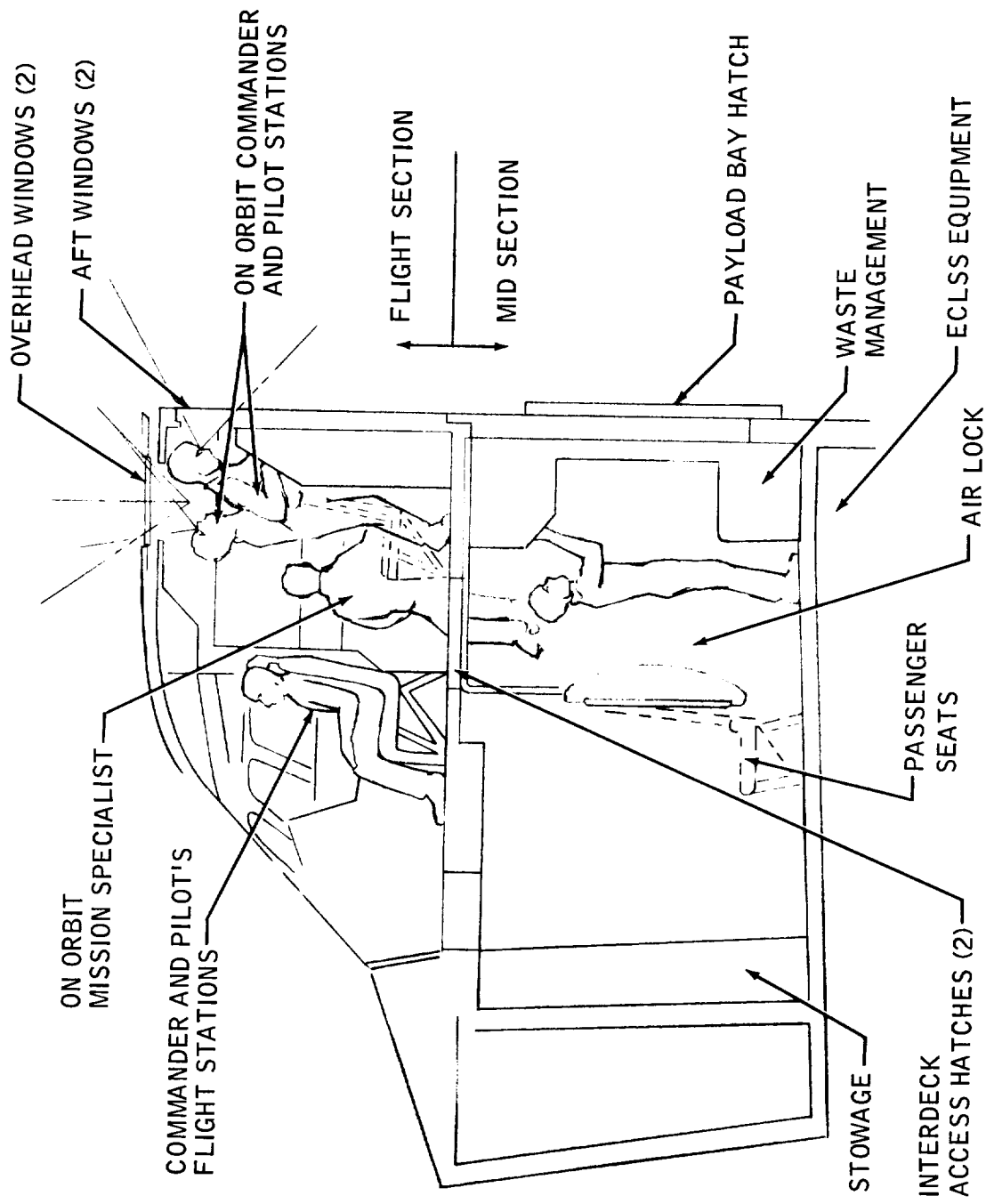


FIGURE 9-1. - CREW COMPARTMENT

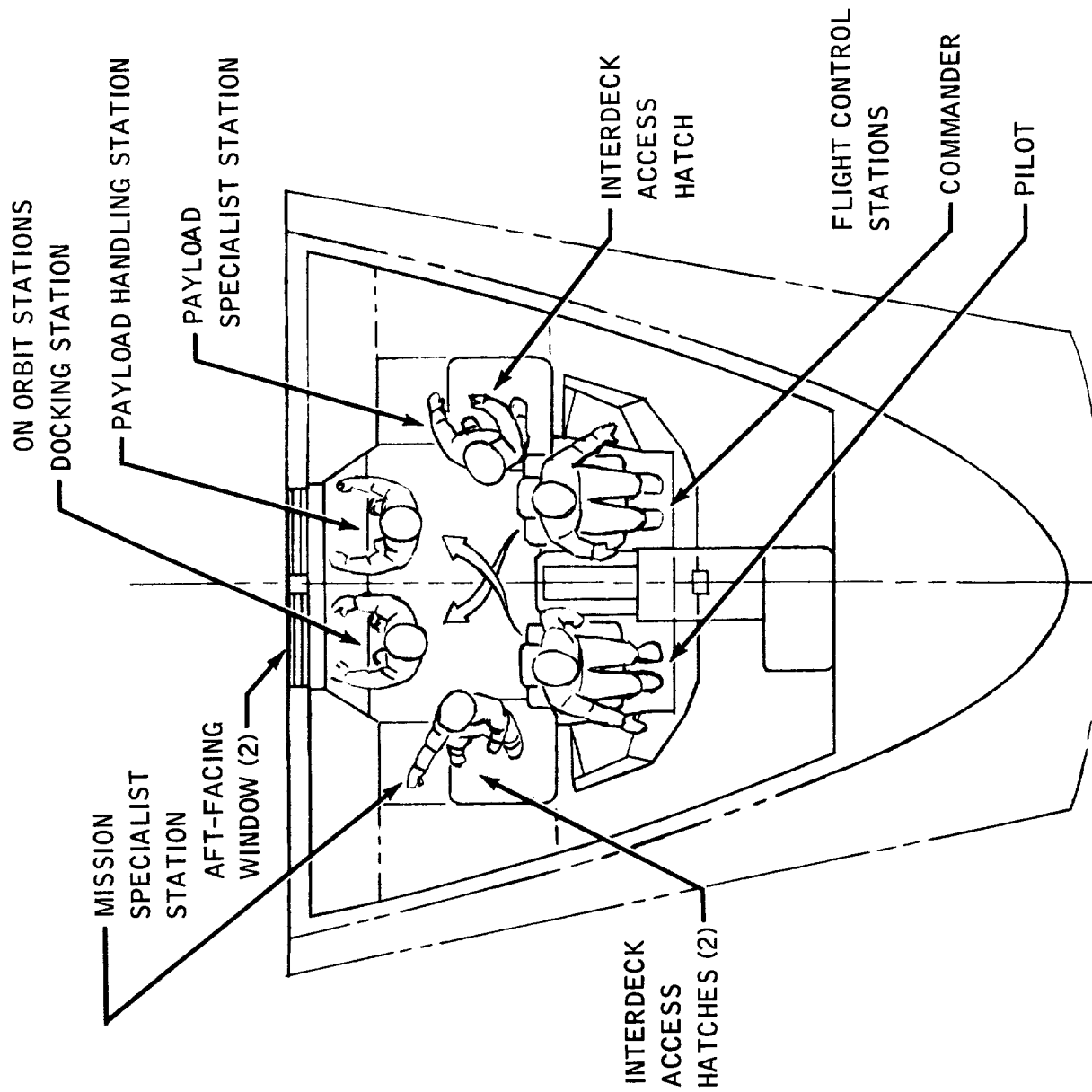


FIGURE 9-2. - CREW COMPARTMENT FLIGHT SECTION CREW STATIONS

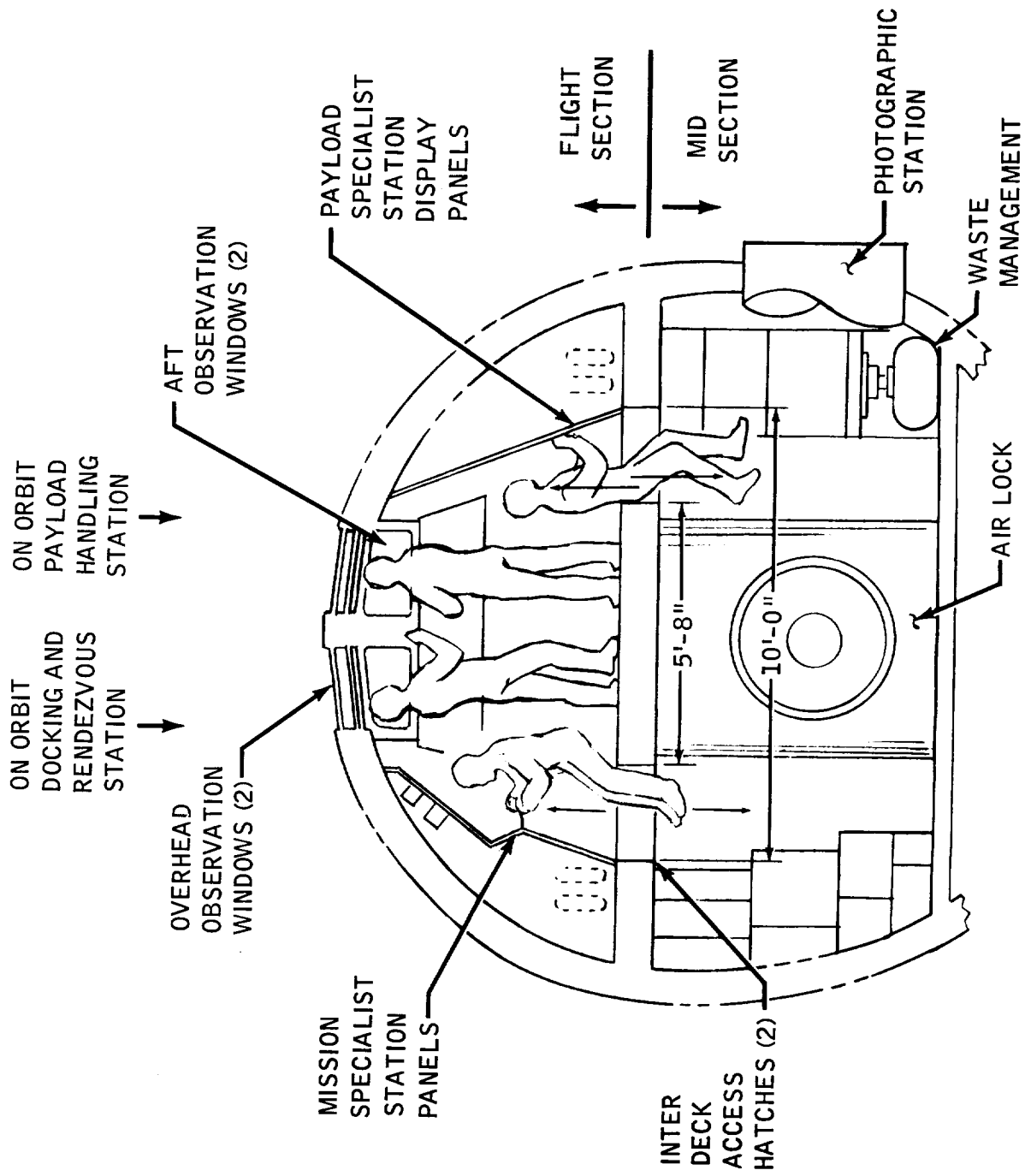


FIGURE 9-3. - CREW COMPARTMENT CREW STATIONS, LOOKING AFT

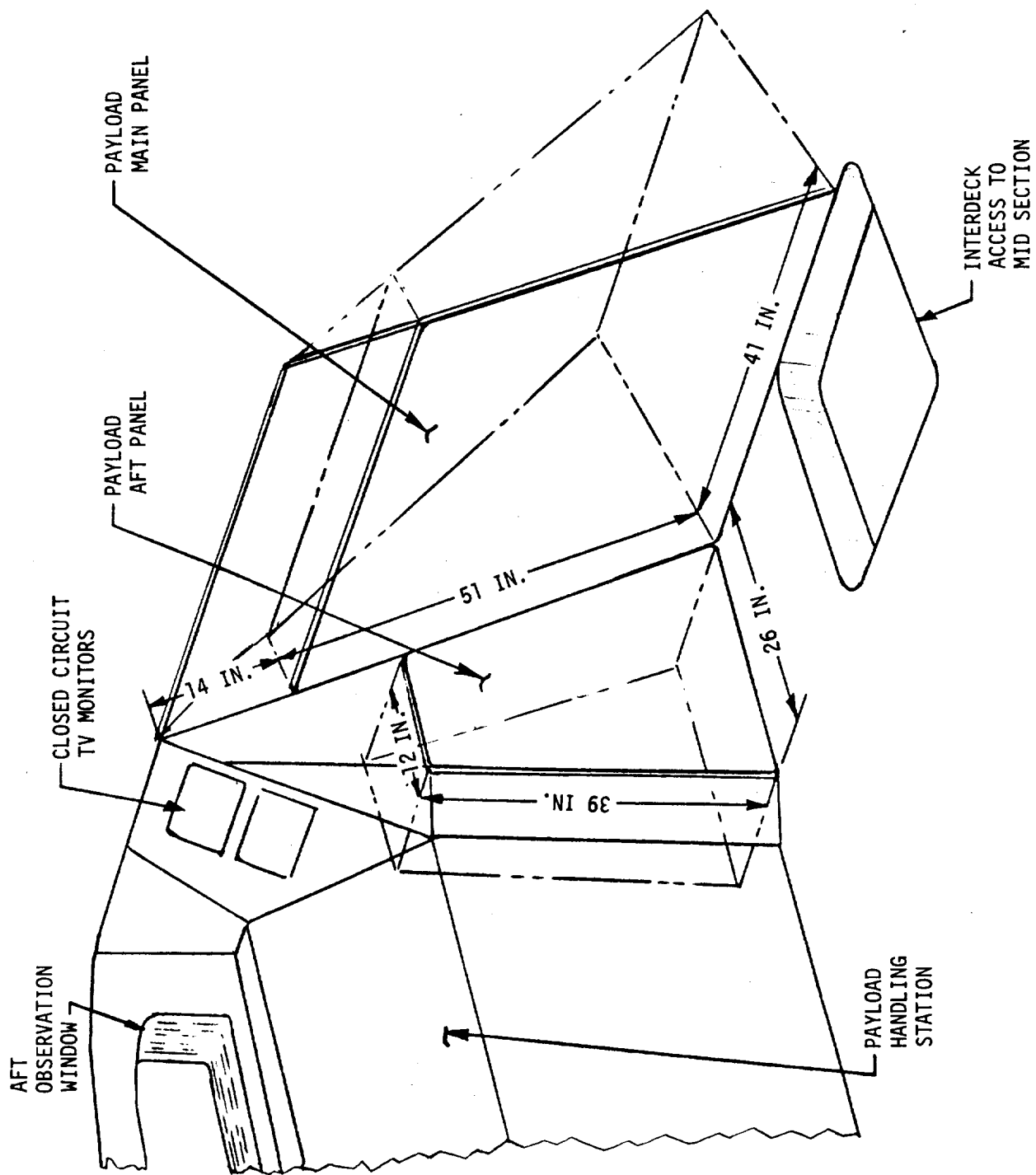


FIGURE 9-4. - PAYLOAD SPECIALIST STATION DISPLAYS AND CONTROL PANELS (PRELIMINARY)

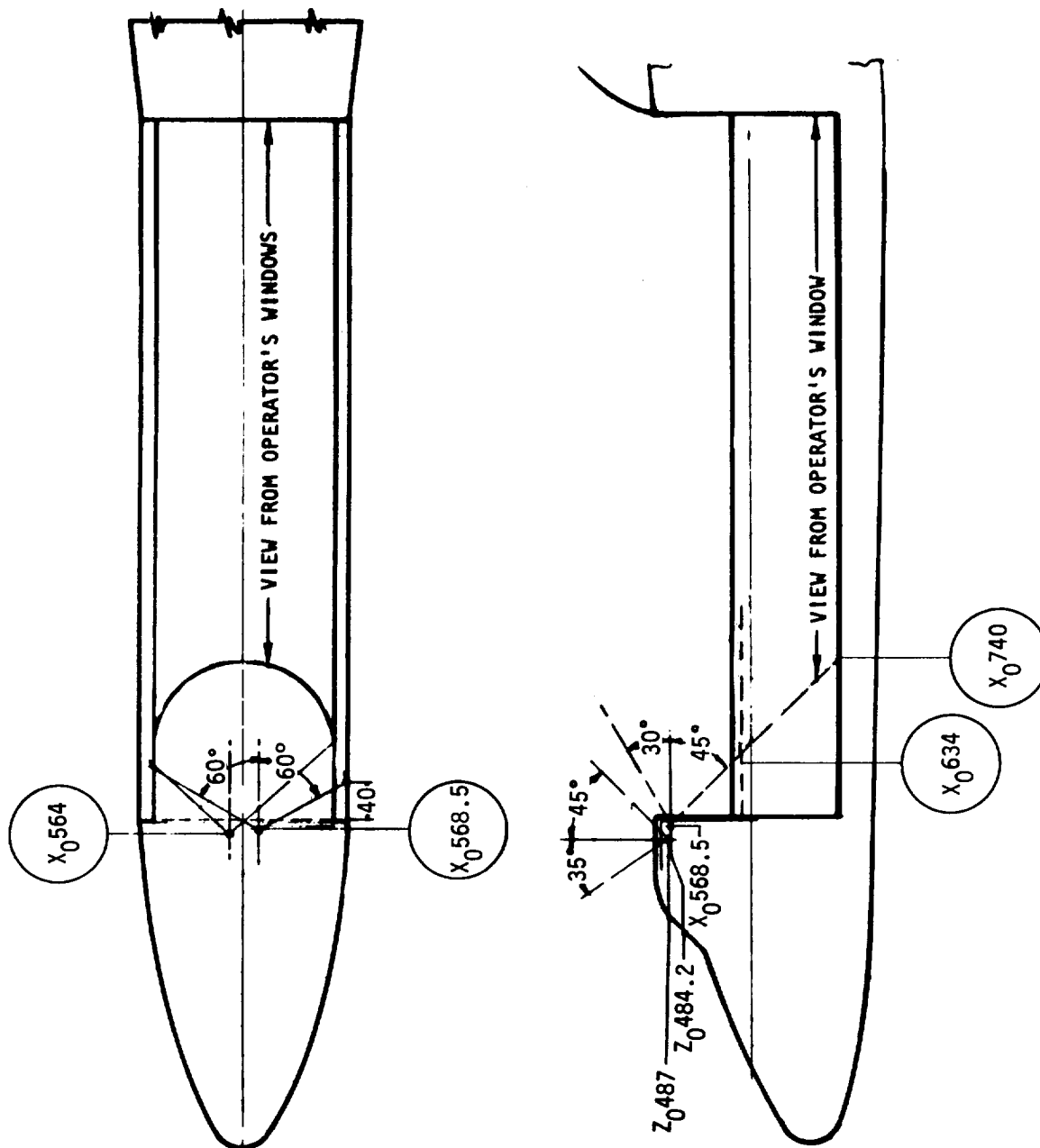


FIGURE 9-5. - FIELD OF VIEW THROUGH AFT AND OVERHEAD WINDOWS

This page intentionally left blank.

10.0 INDUCED ENVIRONMENT

10.1 Vibration. Calculated random vibration levels for the mid-fuselage section of the Orbiter are shown in Figure 10-1. These data are based on scaled data and does not include payload input impedance effects.

10.2 Acoustic. Figures 10-2 and 10-3 give the analytical predictions of the Orbiter payload bay internal acoustic environment and acoustic spectra respectively, and are based on the current midfuselage and payload bay design studies. These predictions will be progressively refined and ultimately confirmed during future tests.

10.3 Shock. This section will be provided later.

10.4 Payload Bay Atmosphere. The Orbiter payload bay can be atmospheric controlled independent of other parts of the Orbiter structure while on the launch pad. Conditioned air purge will be supplied to the payload bay at the launch pad up to 30 minutes prior to propellant loading. At that time, GN2 will be supplied up to lift-off. The purge capability at the Orbiter disconnect interface at the launch umbilical panel is as follows:

- a. Flow rate - 0 to 200 lbs/min.
- b. Temperature - adjustable within the range from 45 degrees F to 120 degrees F controlled to ± 2 degrees F of desired setting.
- c. Class 100,000. See Federal Standard 209A - Clean Room and Work Station Requirements, Controlled Environment.
- d. Air humidity - 0 to 43 grains/pound of dry air.
- e. GN2 humidity - 0 to 1 grain/pound of dry air.

Figure 10-4 shows the payload bay purge configuration.

The Orbiter payload bay is vented during the launch and entry phases and operates unpressurized during the orbital phase of the mission. Figure 10-5 defines the payload bay pressure history during ascent and Figure 10-6 gives payload bay reentry pressure history. Operational characteristics of the payload bay vent system are defined in Figure 10-7. The payload must provide the tankage and gases to accomplish

payload bay repressurization if an inert atmosphere is required for entry.

10.5 Thermal Environment and Control. The determination of payload temperature and temperature environments which the payload will actually experience in the payload bay requires knowledge of the specific mission environment from boost through entry, the type of thermal control provided by the Orbiter and the payload, and the payload bay and payload thermal characteristics. To obtain this information requires detailed knowledge of the actual Orbiter and payload design, as well as the specific inflight orientations which probably will vary for each different mission objective. As Orbiter payload bay and payload thermal criteria are currently envisioned, the following design requirements have been imposed on the Orbiter thermal design.

The internal wall temperature limits for the payload bay, not considering payload heat addition or removal will remain within the ranges noted in Table 10-1.

If the payload bay temperature limits are inadequate, provisions for limited active thermal control of the payload are available from the Orbiter as discussed in Section 8.3. The payload will be responsible for its own passive and/or active thermal control in excess of the prescribed thermal control capacity available from the Orbiter.

Since a total energy allowance of 50 kwh is provided by the Orbiter electrical power system for payload support during a mission, a portion of this power can be utilized for active heater thermal control.

Throughout on-orbit operations, the radiator/payload doors will normally remain open for radiator heat rejection to space. The payload will therefore be exposed to the space environment and must provide for its own passive and/or active thermal control in excess of the prescribed thermal control available from the Orbiter.

10.6 Electromagnetic Compatibility. This section will be provided at a later date.

10.7 Contamination. Particulate contamination levels in the payload bay will be maintained below Class 100,000. To meet these requirements, the following constraints have been established for the payload area:

a. The Orbiter will be designed to minimize the generation, introduction, and accumulation of contaminants which may interfere with payload storage or operation.

b. Materials used on the exterior of the vehicle and in the payload bay will be selected for low outgassing properties.

c. Particulate matter in and around the flight system, both on-orbit and during ground operation will be controlled.

d. On-orbit dumping of excess potable water will be controlled as described in Section 8.2

CONDITION	DESIGN MINIMUM	DESIGN MAXIMUM
Prelaunch	+ 40°F	+ 120°F
Launch	+ 40°F	+ 150°F
On-orbit (doors closed)	See C&D	See A&E
Entry and postlanding	- 100° F	+ 200°F

Heat leak criteria into or out of a 100°F constant payload are as follows:

- A. Total bay heat gain, average ≤ 0 Btu/ft²-hr
- B. Heat gain, local area ≤ 3 Btu/ft²-hr
- C. Total bay heat loss, average ≤ 3 Btu/ft²-hr
- D. Heat loss, local area ≤ 4 Btu/ft²-hr

Table 10-1 Payload Bay Wall Thermal Environment

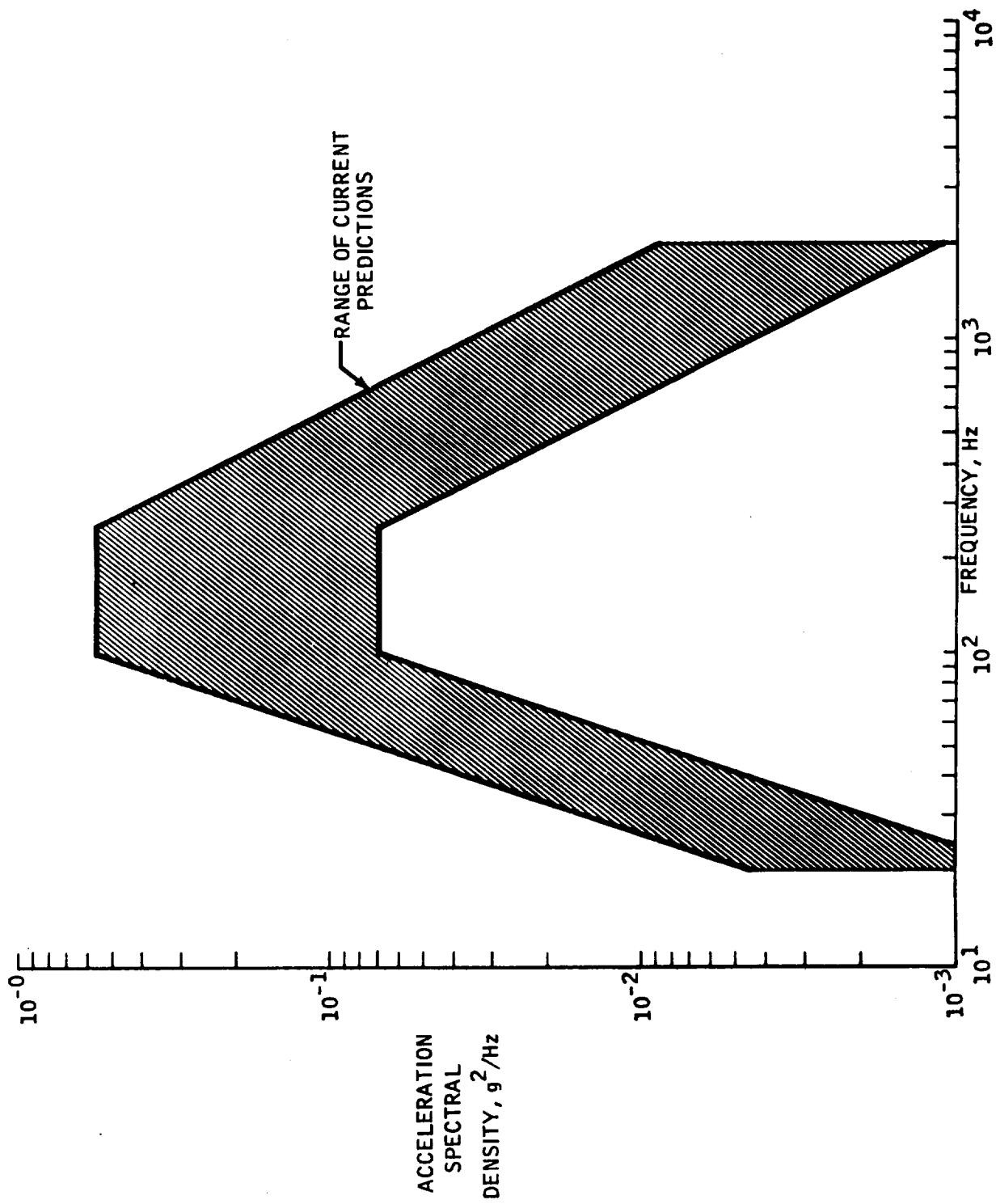


FIGURE 10-1. - ANALYTICAL PREDICTIONS OF THE ORBITER MID-FUSELAGE PRIMARY STRUCTURE VIBRATION SPECTRA

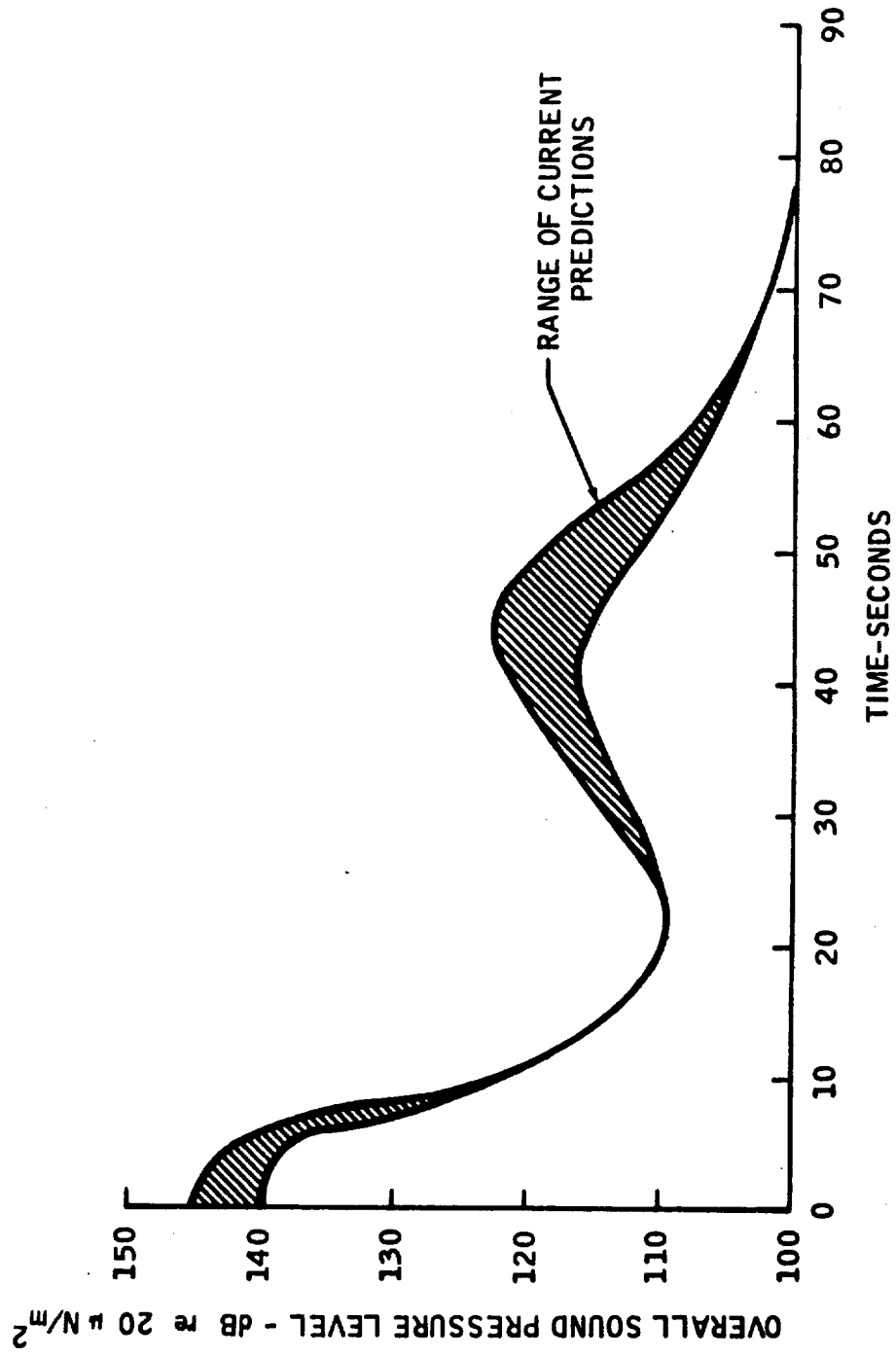


FIGURE 10-2. - ANALYTICAL PREDICTIONS OF THE ORBITER PAYLOAD BAY INTERNAL ACOUSTIC ENVIRONMENT

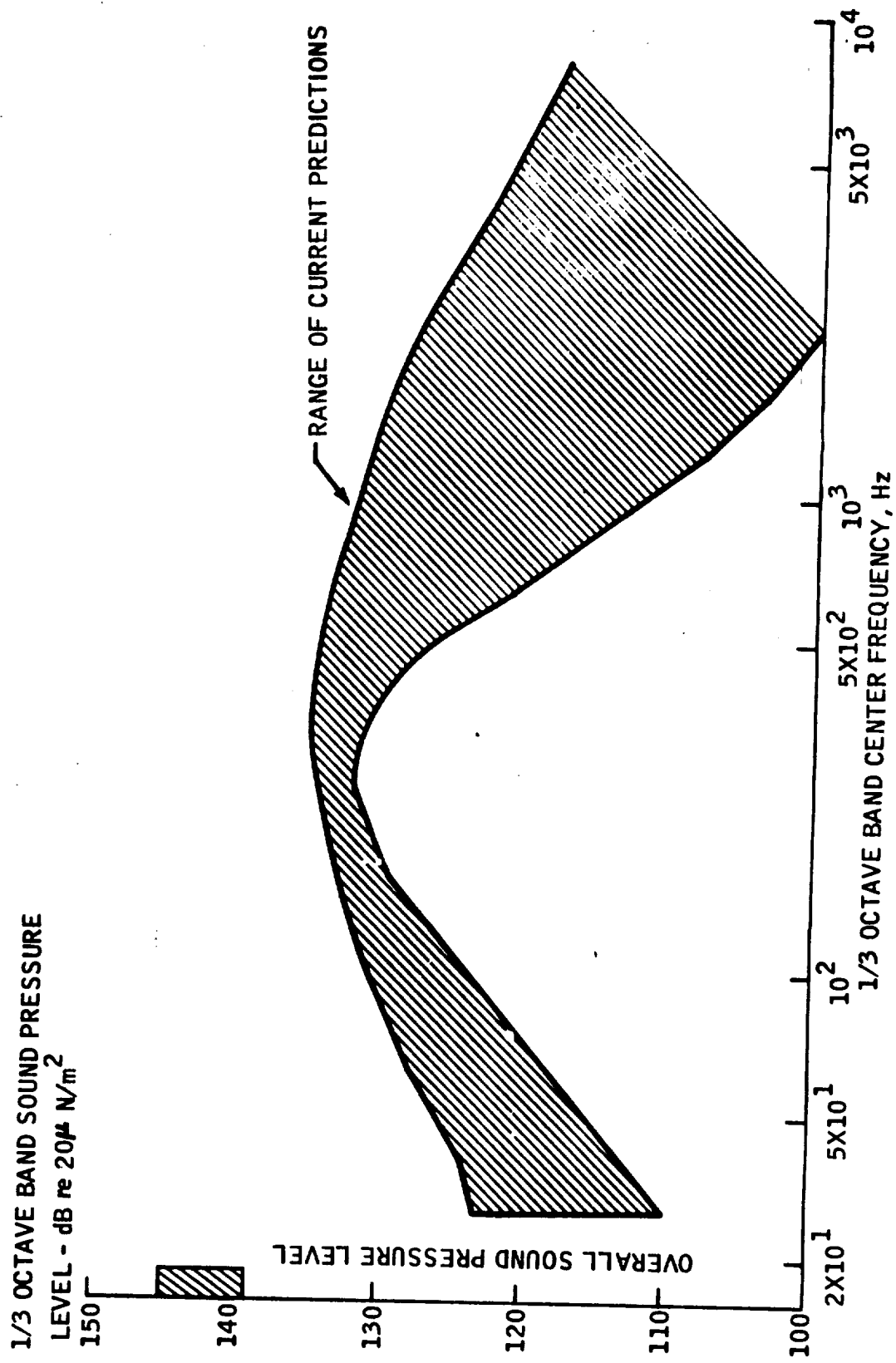
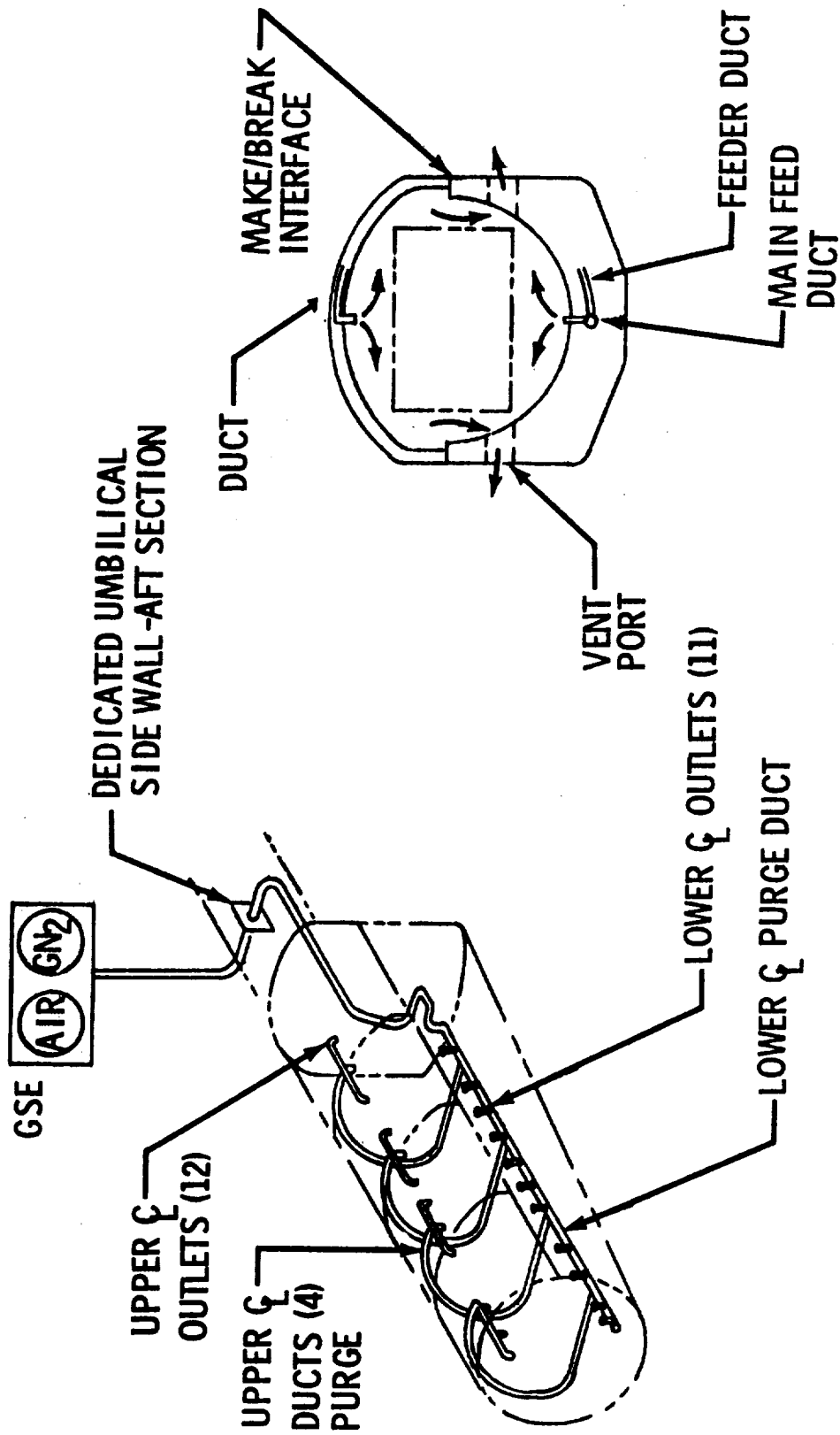


FIGURE 10-3. - ANALYTICAL PREDICTIONS OF THE ORBITER PAYLOAD BAY INTERNAL ACOUSTIC SPECTRA
10-7



- PURGE GAS IS INTRODUCED ALONG TOP AND BOTTOM CENTERLINES AND EXITS THROUGH SIDEWALL VENTS

FIGURE 10-4. - PAYLOAD BAY PURGE SYSTEM

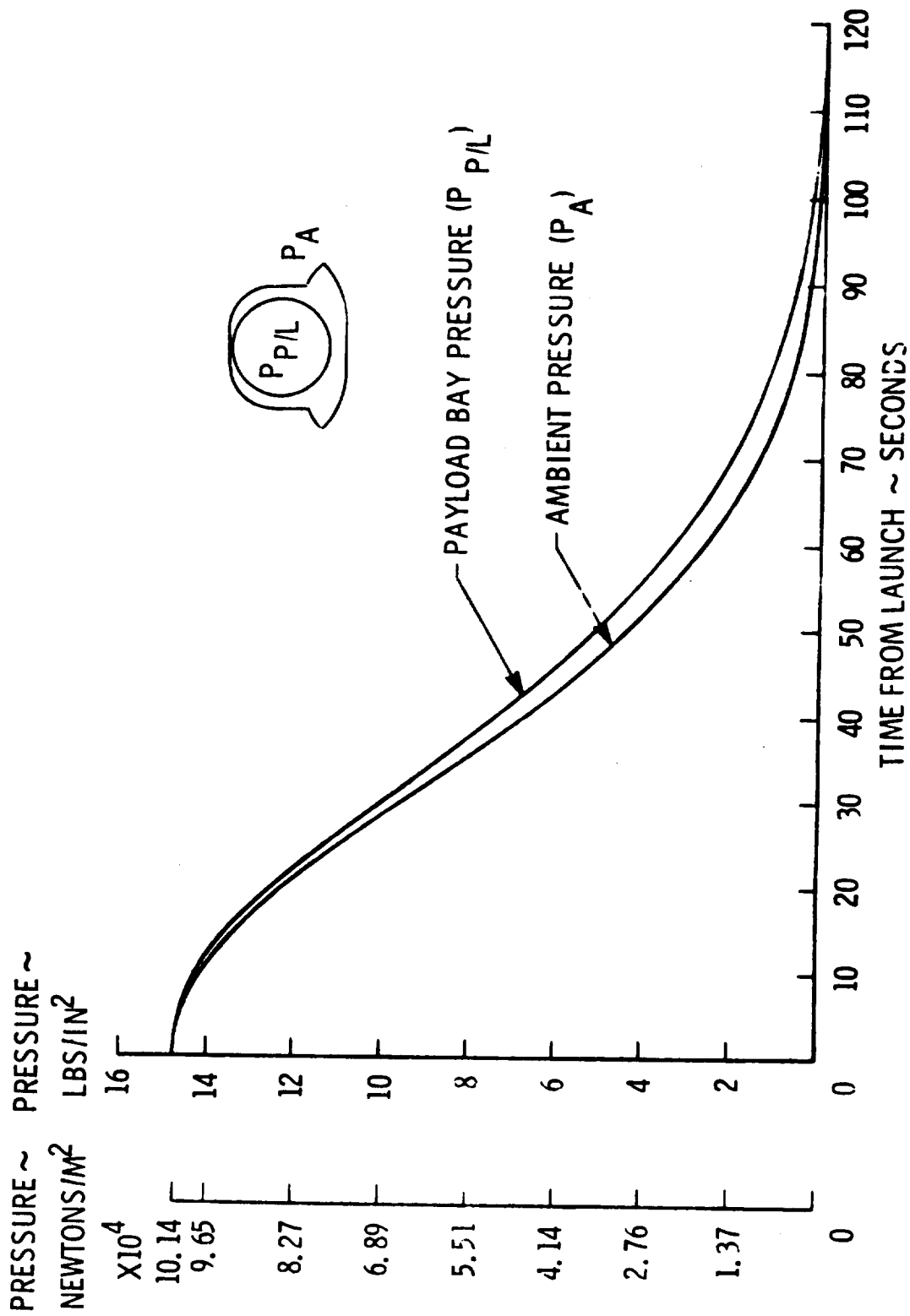


FIGURE 10-5. - PAYLOAD BAY ASCENT PRESSURE HISTORY

**This page reserved for Figure 10-6.
To be supplied at a later date**

Figure 10-7 To be supplied at a later date

This Page Intentionally left blank.

11.0 SAFETY, RELIABILITY, AND QUALITY ASSURANCE

The Space Shuttle System will contain some basic safety capabilities inherent in its design. In addition, it will have dedicated safety equipment to insure the safety of the Orbiter and its flight crew. Safety design features include abort capability, caution and warning subsystem, vent provisions, and dry nitrogen inerting purge prior to launch. Specific safety equipment and capabilities aboard the Orbiter are TBD.

Commensurate with the Space Shuttle Program (SSP) objective of providing a low cost space transportation system, the SSP requires that payload suppliers meet NASA safety requirements, but the SSP has no responsibility for payload performance. Payload performance is the responsibility of the payload supplier. There will be no independent SSP imposed reliability and quality assurance requirements.

The payload suppliers are fully responsible to NASA for the following safety requirements:

a. The determination of the hazardous aspects of the payload and the implementation of required corrective measures.

b. Assurance of the compatibility of the payload with Space Shuttle System interfaces.

c. Identification of residual hazards and interface incompatibilities prior to payload summary reviews and inspection.

Preflight summary reviews and inspections of payloads will be conducted with participation by the payload suppliers to verify that NASA safety requirements have been met.

This page intentionally left blank.

12.0 KSC SPACE SHUTTLE SYSTEM GROUND OPERATIONS

A typical Space Shuttle System ground flow is shown in Figure 12-1. Figure 12-2 shows the typical flow time for the Orbiter during its turnaround time and the times during the flow for payload installation and removal.

After the Orbiter has landed, preliminary securing operations including the connection of the mobile ground cooling unit, crew egress, and establishment of ground communication prior to towing the Orbiter to the Orbiter Maintenance Facility (OMF) where safing tests will be performed. The OMF is an environmentally controlled facility that will be maintained at a Class 100,000 environment. Upon arrival of the Orbiter at the safing and deservicing cell of the OMF, postlanding safing activities will begin with deactivation of hazardous ordnance, propulsion, and electrical (fuel cell tanks and APU) systems. In addition, electrical ground power and environmental equipment will be connected to the Orbiter.

After the completion of the safing activities, the payload bay doors will be opened, access equipment installed, and the payload removed. At the conclusion of the maintenance activities, the payload will be installed in the Orbiter bay which had been previously cleaned to a visibly clean level (Level-TBD). Figure 12-3 shows the current horizontal payload installation concept. Prior to the payload bay doors being closed, an Orbiter integrated test will be conducted to verify the interfaces between the payload and the Orbiter. The payload bay environment with the doors closed will be maintained by providing a facility purge of Class (TBD) air at (TBD)° F temperature and (TBD) percent relative humidity. The payload will not normally be accessible after closure of the payload bay doors until the entire stack is mated at the launch pad except through the Orbiter cabin.

Upon completion of the OMF activities, the Orbiter will be towed to the VAB for transition from the horizontal to the vertical position. Premate activities will be accomplished to prepare hoisting the Orbiter to be mated with the external tank and solid rocket boosters. When mating of the shuttle elements on the mobile launch platform (MLP) are complete in the VAB, the facility will provide a purge of Class (TBD) air at (TBD)° F temperature and (TBD) percent relative humidity to the payload bay.

Following the completion of mating and Orbiter interface verification checks with the mobile launcher platform, the stack will be rolled out on the crawler transporter to the pad while maintaining the Class (TBD) air purge to the payload bay. After the MLP has been mated to the pad, and umbilicals connected, an interface verification test will be run to verify the integrity and serviceability of the Pad/Shuttle System interfaces. An abbreviated avionics overall test will be performed prior to hypergolic and related pneumatic subsystems servicing.

In the event that the payload must be installed in the Orbiter in a vertical position at the Pad, the payload will be directly transported to the Pad and installed in the payload bay. Figure 12-4 shows the current vertical payload installation concept. During this operation, the Orbiter will be enclosed by an environmentally controlled payload change-out room. The payload bay will be purged with Class (TBD) air at (TBD) ° F temperature and (TBD) percent relative humidity during the installation of the payload in the Orbiter. A payload can be removed from the Orbiter on the launch pad and a new payload installed within a time period of ten hours up to T-2 hours. Environmental control requirements will be met during the exchange.

After the Shuttle Flight System and payload interfaces have been connected and verified at the launch pad, a launch readiness checkout followed by prelaunch servicing and preparation, propellant loading, crew ingress, final countdown, and launch will be conducted.

The capability for payload checkout and component replacement in the vertical position will be possible through the Orbiter payload bay doors and through the Orbiter crew compartment/payload bay hatch. Access to, removal of, and loading of payload items on the pad must be accomplished no later than TBD hours prior to launch.

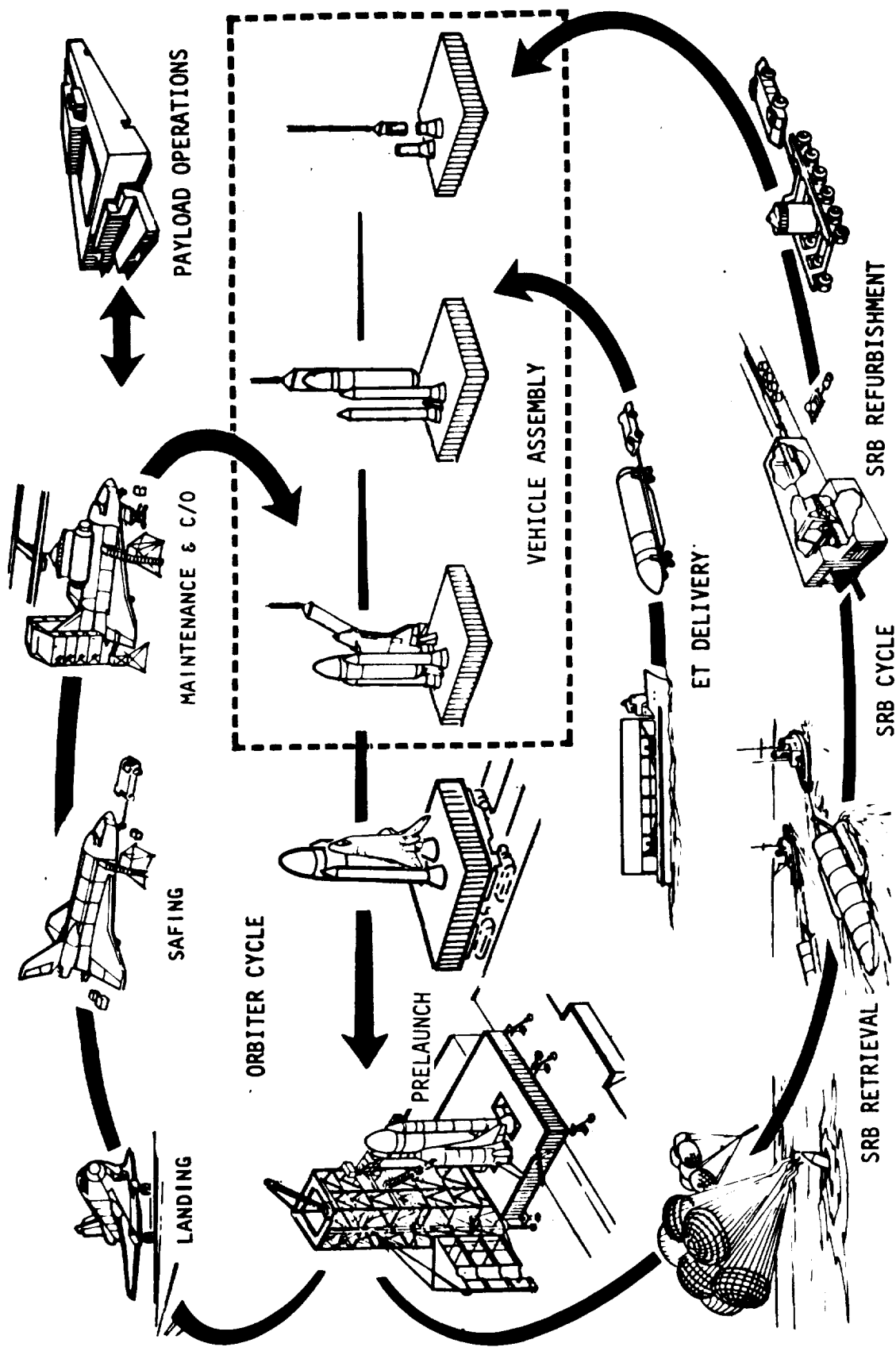


FIGURE 12-1. - KSC SPACE SHUTTLE SYSTEM GROUND FLOW

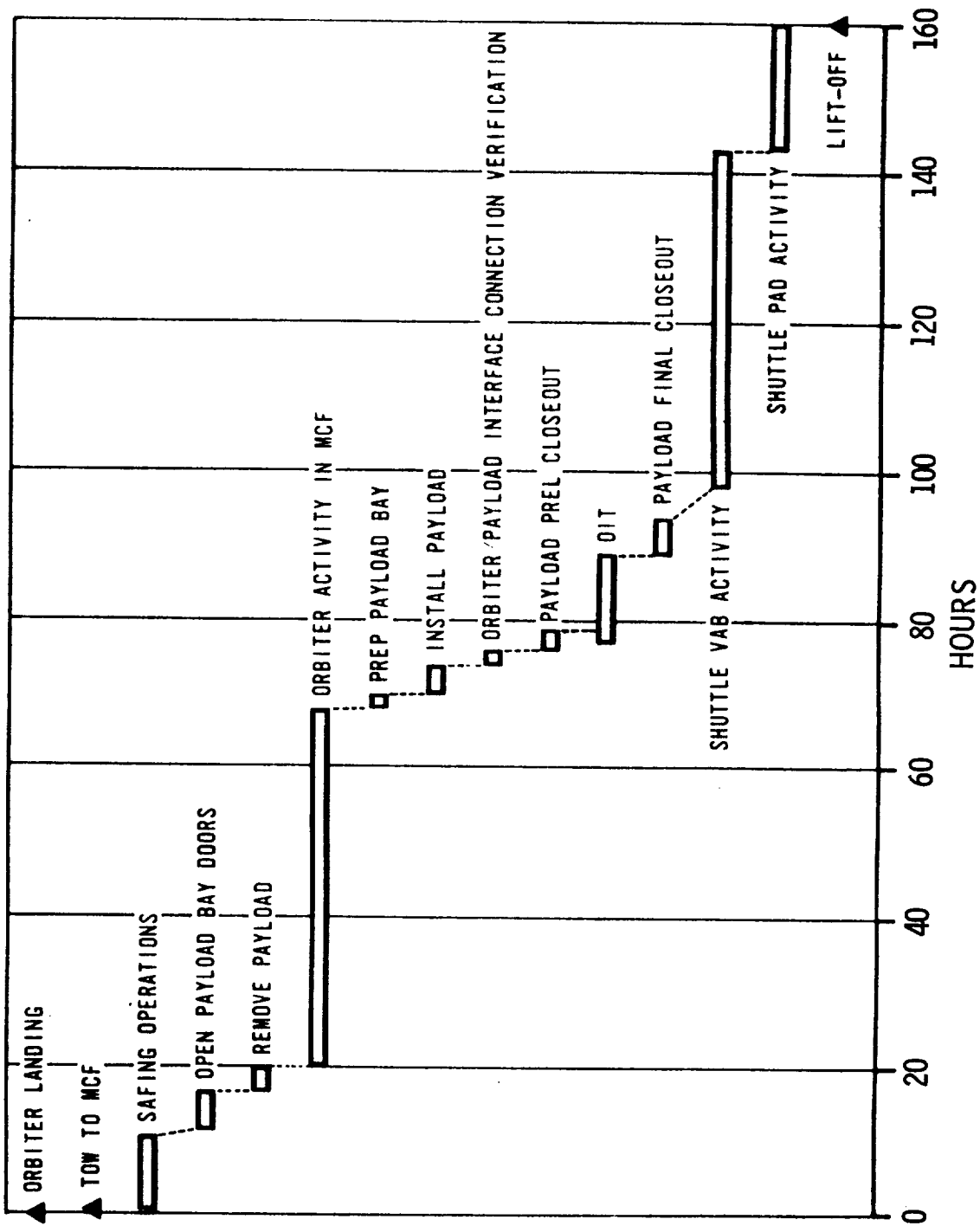


FIGURE 12-2. - KSC SPACE SHUTTLE GROUND FLOW (PRELIMINARY)

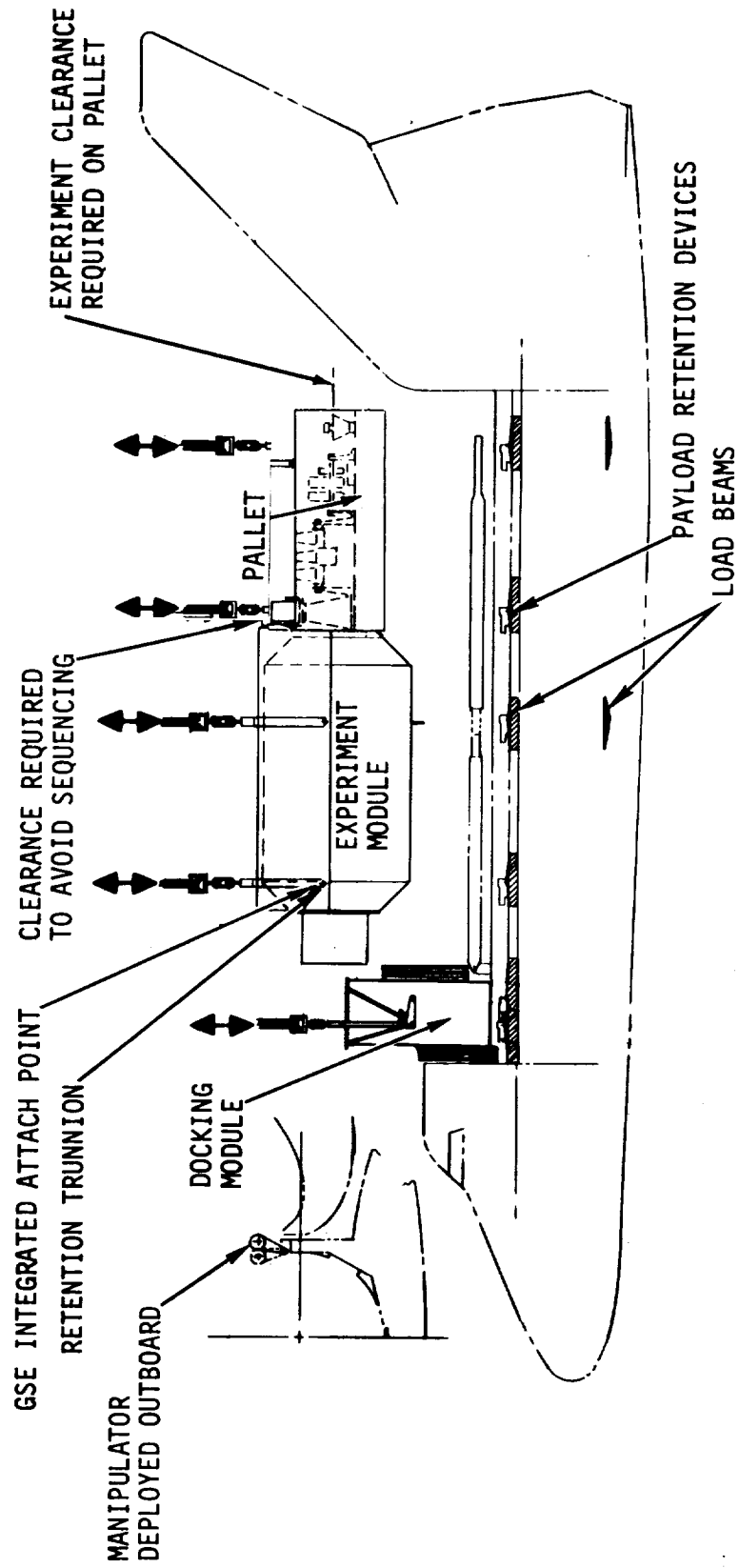


FIGURE 12-3. - HORIZONTAL PAYLOAD INSTALLATION/REMOVAL CONCEPT

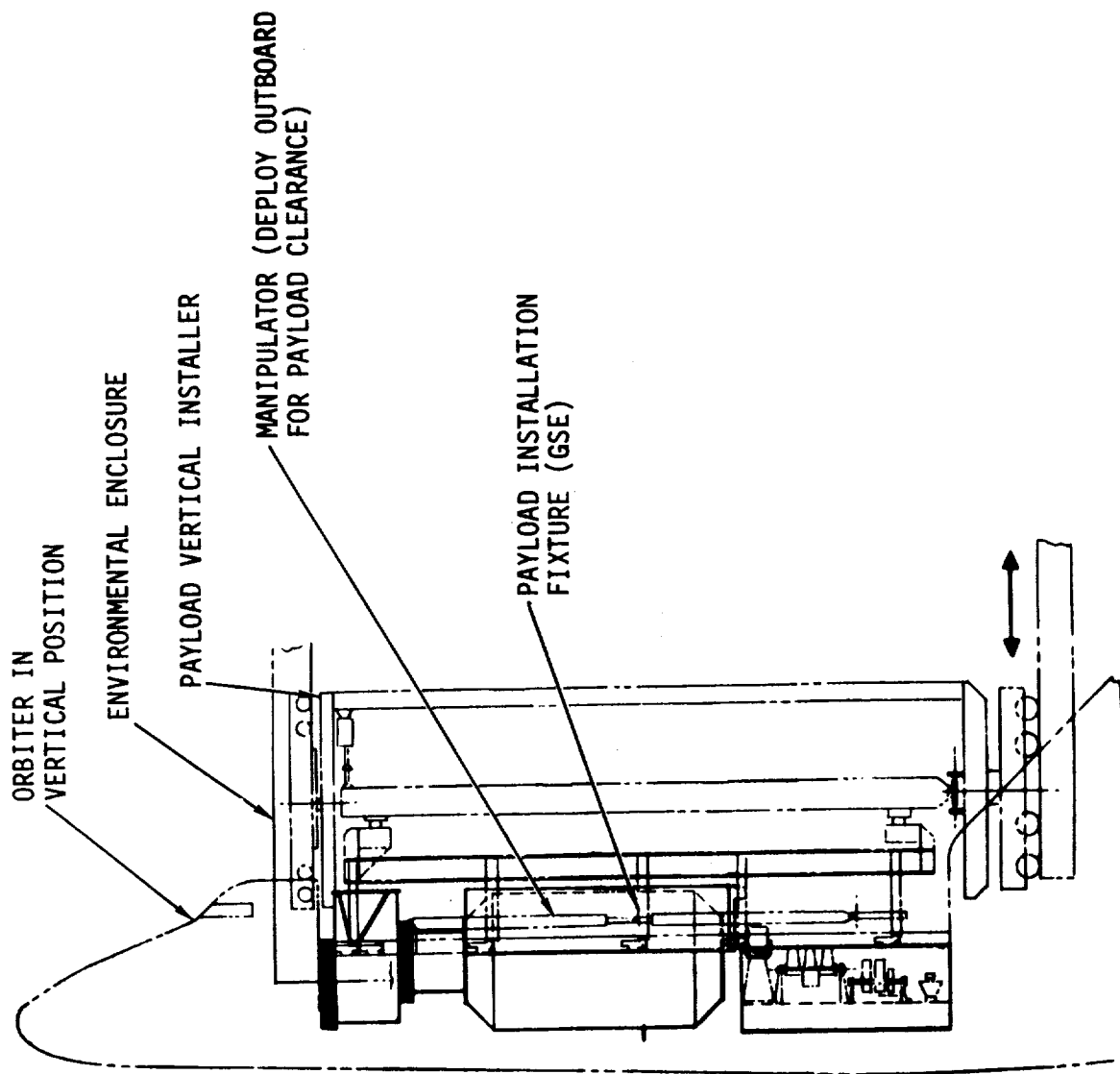


FIGURE 12-4. - PAYLOAD VERTICAL INSTALLATION/REMOVAL CONCEPT

APPENDIX A

ABBREVIATIONS AND ACRONYMS

AM	Amplitude Modulation
ARS	Atmospheric Revitalization Subsystem
ATCS	Active Thermal Control Subsystem
Btu	British Thermal Unit
c.g. or CG	Center of Gravity
CO ₂	Carbon Dioxide
db	Decibel
Delta-V or	Velocity Change in Feet per Second
ECIS	Environmental Control and Life Support
EVA	Extravehicular Activity
FM	Frequency Modulation
fps	Feet per Second
g	Acceleration Due to Gravity
GN ₂	Gaseous Nitrogen
GN&C	Guidance, Navigation and Control
Hz	Hertz (Cycles)
K	1,000
Kbaud	Code elements per second in 1,000's
Kbps	Bits per Second in 1,000's
KSC	Kennedy Space Center
km	Kilometers
kw	Kilowatt
kwh	Kilowatt Hours
lbs	Pounds
LH ₂	Liquid Hydrogen
LiOH	Lithium Hydroxide
LO ₂	Liquid Oxygen
MDM	Multiplexer-Demultiplexer
MECO	Main Engine Cut-Off
MHz	Megahertz
N.MI or n.mi	Nautical Miles
OMS	Orbital Maneuvering Subsystem
PCM	Pulse Code Modulation
PLH	Payload Handling
PLM	Payload Management
PCP	Perpendicular to Orbit Plane
psi	Pounds per Square Inch
psia	Pounds per Square Inch Absolute
q or Q	Aerodynamic Pressure
RCS	Reaction Control Subsystem
RF	Radio Frequency
RMS	Remote Manipulator System
RSS	Root Sum Square
SRE	Solid Rocket Booster
SSP	Space Shuttle Program

STDN	Space Tracking and Data Network
TED	To Be Determined
TDRS	Tracking and Data Relay Satellite
TV	Television
VAFB	Vandenberg Air Force Base
VDC	Volts Direct Current
VHF	Very High Frequency

APPENDIX E
GLOSSARY

Airlock -	A compartment, capable of being depressurized without depressurization of the cabin, used to transfer crewman and equipment.
Berthing -	The use of the remote manipulator system to softly bring together an orbital element and the Orbiter.
Beta Angle -	The minimum angle between the earth-sun line and the plane of the orbit.
Caution -	Any out-of-limit condition or malfunction of a system that affects primary mission objectives or could result in loss of a system if not responded to in time. Crew action is required, although not immediately.
Cooperative Target -	A cooperative target (payload) is a three axis stabilized critical element which has enhanced electromagnetic reflection or signal characteristics.
Dead Band -	That positive or negative value of attitude error in any body axis beyond which the attitude thrusters are activated when the rate error is zero.
Docking Module -	A module which allows positive interception, engagement and release of the orbiter vehicle with another orbiter vehicle or other orbital elements containing like docking mechanisms.
Emergency -	Any condition which can result in crew injury or threat to life and requires immediate corrective action, including predetermined crew response.

Extravehicular Activity -	Crewman activities conducted outside the spacecraft pressure hull or within the payload bay when the payload doors are open.
Habitable Payload -	A payload with a pressurized compartment suitable for supporting a crewman in a shirtsleeve environment.
Inclination -	The maximum angle between the plane of the orbit and the equatorial plane.
Intravehicular Activity -	Crewman activities inside the spacecraft, within a payload module carried in the payload bay, or within the payload bay when the doors are closed. The term IVA is dependent upon where the activity is performed and is independent of local atmospheric pressure.
Launch Pad -	The pad area from which the Space Shuttle will be launched. The stacked Space Shuttle will undergo final prelaunch checkout and count-down at the launch pad.
Launch Processing System (LPS) -	A high speed digital computer operated checkout system used to support test, checkout, launch control and operational management of launch site ground operations at KSC.
Manned Spacecraft Operation Building (MSOB) -	This is the building at KSC that has been used for vehicle checkout in the vacuum chambers and checkout prior to transfer to the VAB for stacking. It is commonly called the O&C (Operations and Checkout) building.
Mobile Launch Platform -	The elements of the Space Shuttle will be stacked upon the mobile launch platform while in the Vehicle Assembly Building (VAB).

	After stacking, it will be rolled cut to the launch pad.
Multiple Payloads -	More than one separate payload carried in the cargo bay.
Orbiter Checkcut Facility -	This is a building at KSC with two high bays in which the Orbiter is rolled in and out on its tires and undergoes post flight inspection, maintenance, premate checkout prior to integration with the other elements and possible payload installation.
Passive Target -	A passive target (payload) is a three axis stabilized orbital element which is detected, acquired and tracked by means of electromagnetic energy reflected from the skin of the target.
Payload -	Any payload carrier, experiment equipment, sensors, and subsystems which are contained within the Orbiter 15 x 60 foot cargo bay.
Payload Carrier -	Refers to major classes of standard payload carriers certified for use with the Space Shuttle to obtain low cost payload operations. The payload carriers are identified as habitable modules (Space Lab), and attached but uninhabitable modules (pallet, free flyer, satellites, and propulsive stages).
Payload Changeout Room -	This is an environmentally controlled white room clamped around the payload bay. It is installed either in the maintenance and checkout facility or launch pad depending upon where the payload is installed.
Payload Supplier -	Owner/operator of any Space Shuttle payload.
Reference Missions -	Mission profiles to be used in

conjunction with other specific systems requirements to size the Space Shuttle vehicle.

Retrieval -

Is herein intended to mean those operations associated with the grappling and maneuvering of the target vehicle into the Orbiter payload bay.

Stability Rate -

The maximum angular rate error during steady state limit cycle operation.

STDN -

Is the Spaceflight Tracking and Data Network. It generally means a number of ground based systems (stations) having direct communications with NASA flight vehicles. Although technically incorrect, as used in this document, generally includes point-to-point circuits (NASCOM) between the remote sites (stations) and the Mission Control Center. Also, as herein used, does not include TDRSS, although GSFC intends that TDRSS become a part of STDN when operational.

TDRS -

Is the Tracking and Data Relay Satellite to be used by NASA for communications between the flight vehicle and ground. As is, includes only the satellites, of which there are two (2) active planned, located at geosynchronous altitude, and separated in longitude by about 120°. When used with a second "S", (i.e. - TDRSS), it includes the ground system required to work with the satellites, (i.e. - Tracking and Data Relay Satellite System).

Vehicle Assembly Building (VAB) -

This is the building at KSC that has four high bays that is used for vertical storage of the external tanks and to stack the Shuttle elements onto the mobile launch

platform. This begins with solid rocket motor buildup on the mobile launcher, installation of the external tank, turning the orbiter to the vertical position and tying it to the stack and ends in integrated checkout of the completed Space Shuttle.

Warning -

Any existing or impending condition or malfunction of a system that would adversely affect crew safety or compromise primary mission objectives. Immediate action by the crew is required.

This page intentionally left blank.

APPENDIX C

Payload Accommodations Baseline Drawings

The drawings contained in this appendix represent the current Space Shuttle System baseline relating to Payload Accommodations. These drawings have not been placed under formal Level II control and therefore are subject to change without notification.

<u>Drawing Number</u>	<u>Payload Accommodations</u>
VL70-003267	Forward Fuselage Provisions
4105	Envelope/Retention & Loading
4145	Payload Handling and Viewing
4146	Mid-Fuselage System Interface
4150	Ground Handling Provisions
5126	Aft Fuselage Provisions

PRECEDING PAGE IS A FILMED

B-6 PRECEDING PAGE IS A FILMED

